MARINE ENGINEERING.

Vol. 5. NEW YORK, FEBRUARY, 1900. No. 2.

U. S. FLOATING DRY DOCK AT ALGIERS, LA.—LARGEST IN THE WORLD.

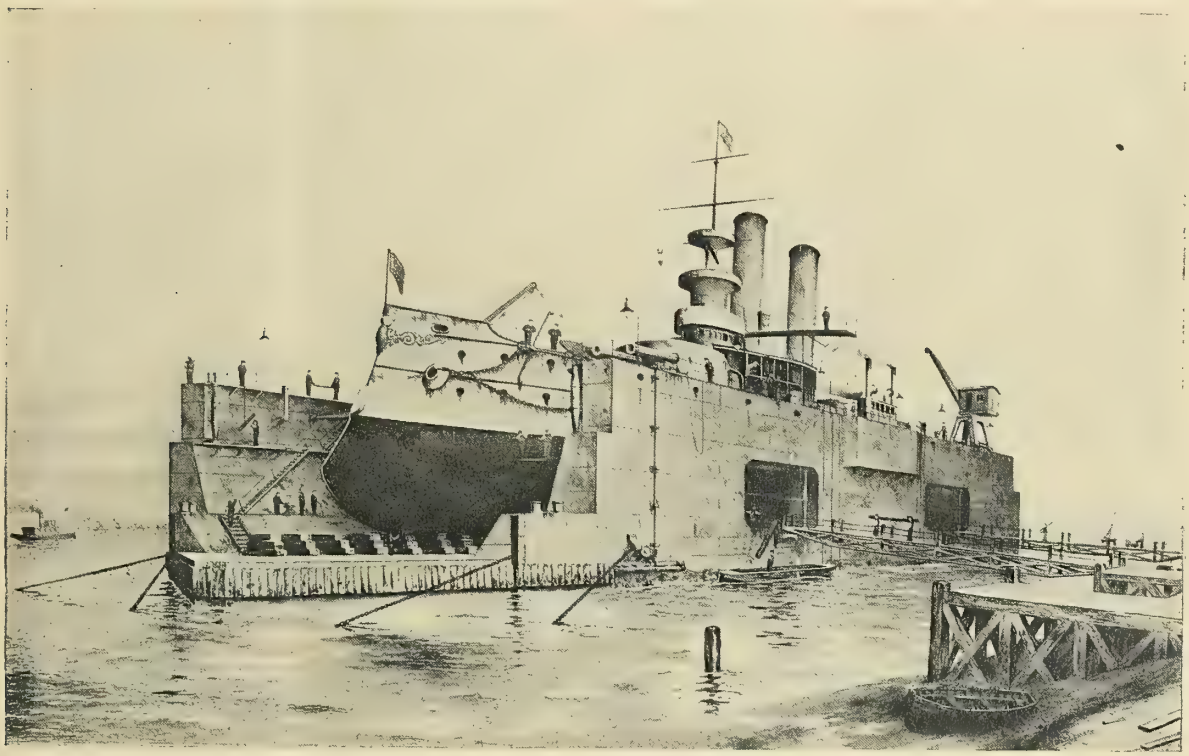
In considering the type of dock, whether sunk or floating, to be located at the U. S. naval reservation at Algiers, opposite New Orleans, La., the local physical characteristics of the site were determining factors in the decision.

With the strong current of the Mississippi rendering it difficult and at times impossible to turn a ship across it; with a soil of clay and sand affecting the stability of a sunk dock, and, finally, with a difference of nearly 20 ft. between high and low water stages of the river, adding enormously to the cost of a sunk dock, it was easily apparent that a floating dock alone could meet these conditions.

Accordingly, in the Act of May 4, 1898, Congress made an appropriation for a combined floating and graving dock of steel, capable of lifting an ironclad of 15,000 tons, with a draft of 27 ft., to be located at the Algiers naval reservation.

In August, 1898, bids for this dock based on "general specifications" were called for by the Bureau of Yards and Docks, bidders being free to present their own plans, with a limit of cost of the "entire works" of $850,000.

The proposal of the Maryland Steel Co., with plans drawn by Clark & Stanfield, of London, England, was found to be lower in price ($810,000) than its single competitor, and was considered to be of greater merit in other particulars. The contract was therefore awarded to the Maryland Steel Co. on its bid of $810,000, which includes the cost of shore connections, towage, and insurance. This contract was executed in April, 1899, and must be completed in November, 1900, a period of 18 months.



SKETCH SHOWING U. S. FLOATING DOCK FOR ALGIERS, LA., AS IT WILL APPEAR WITH BATTLESHIP DOCKED.

The first proposal of the company was for a lifting capacity of 15,000 tons, but the 2 ft. of freeboard

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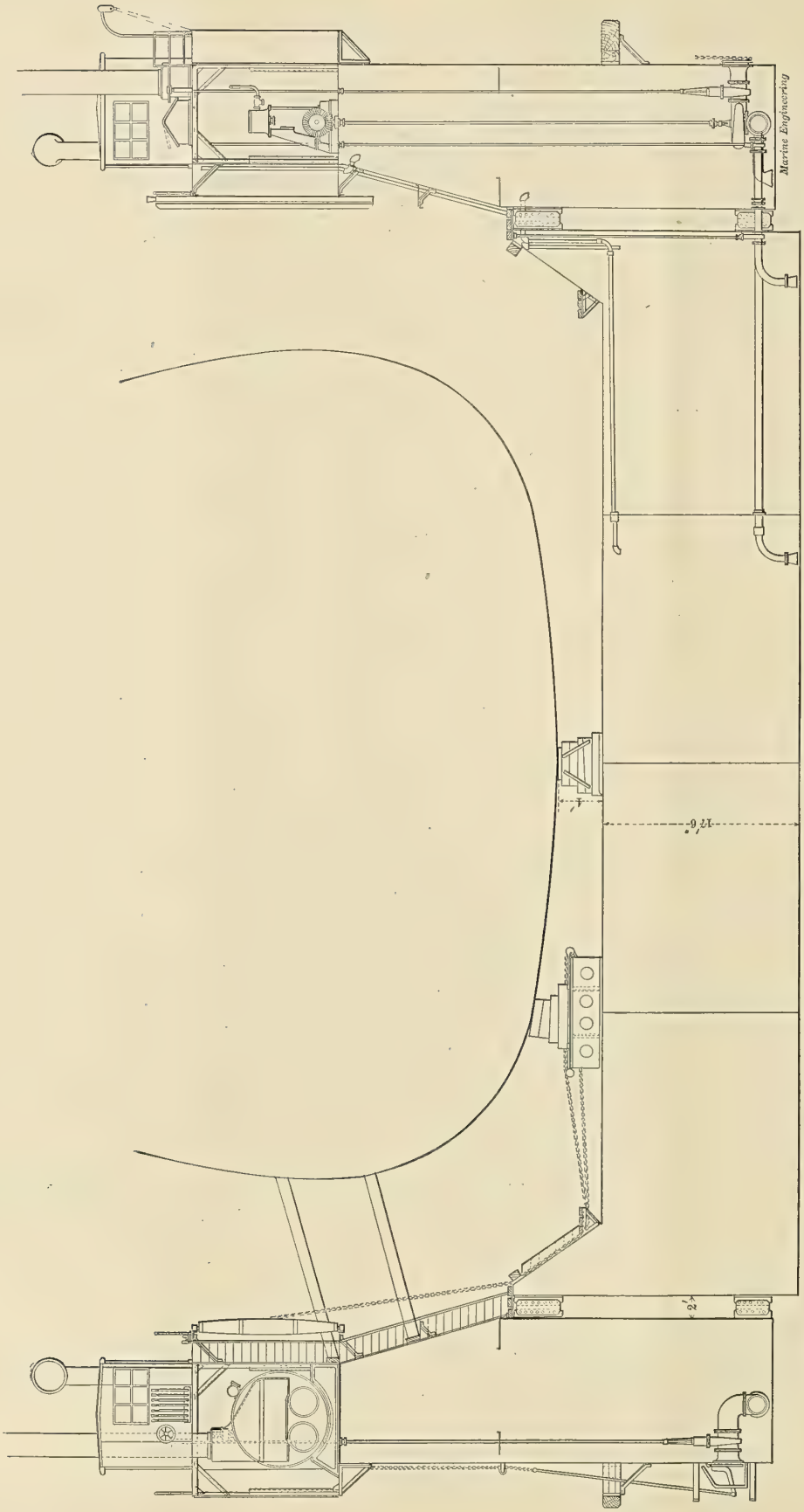
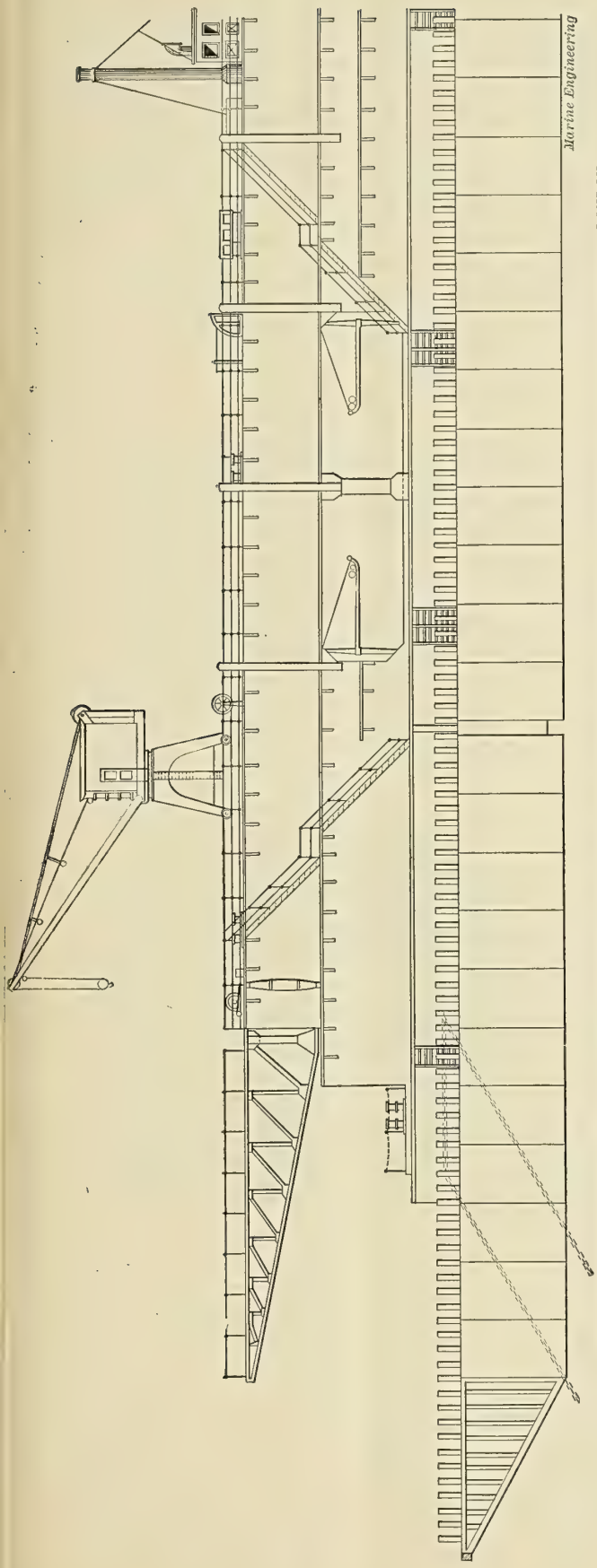


CROSS MID-SECTION OF U. S. STEEL FLOATING DOCK FOR ALGIERS, LA., NOW UNDER CONSTRUCTION BY MARYLAND STEEL CO., SPARROW'S POINT, MD.



HALF LENGTH OUTBOARD PROFILE OF U. S. STEEL FLOATING DOCK FOR NAVAL RESERVATION, ALGIERS, LA.—DESIGNED BY CLARK & STANFIELD, LONDON.

required by the Bureau's specification was secured by the use of gates. This was not allowed by the Bureau, and the plans were modified by increasing the depth of the pontoons, so that with the increased power, and without the use of gates, a 15,000-ton ship could be lifted 2 ft. above the surface of the water. These modified plans were accepted, with the result that the Navy will acquire a dock with a maximum capacity of 18,000 tons, when the floor is awash, or 15,000 tons with a freeboard of 2 ft. In effect the dock will be the most powerful floating dock in the world, and will be able to lift the largest ship ever built.

The designers, Clark & Stanfield, who have also made plans for many other docks, including the Havana naval dock of 10,000 tons, and the Stettin commercial dock of 11,000 tons, have in the Algiers dock improved on the two earlier docks mentioned in the direction of strength and simplicity.

The following are the general dimensions of the Algiers dock:

Length over all	525 ft.
Breadth " "	126 ft. 2 7-16 in.
Breadth between walls	100 ft.
Depth over sills	28 ft.
Depth of pontoons	17 ft. 6 in.
Height of keel blocks	4 ft.
Maximum draft	49 ft. 6 in.
Number of pontoons	3
Length of middle pontoons	242 ft.
" " end "	141 ft. 3-8 in.
" " walls	395 ft. 5-8 in.
Width " "	12 ft. 1 1-8 in.
Clearance of walls and pontoons	2 ft.
Freeboard of walls, 28 ft., on sills	4 ft. 9 in
Number of keel blocks	209
Weight of dock	5,702 tons
" " equipment	420 tons
" total of dock	6,122 tons
Lifting powers of dock (maximum)	18,000 tons
Time of lifting " "	3 1-2 hours
Cost of dock	$810,000
Time penalty for delay	$200 per day

The material used is generally acid or basic open hearth steel.

The specifications require that the dock shall have transverse strength and stiffness sufficient for docking a battleship of 15,000 tons with her entire weight carried on the keel blocks. The dock must not careen more than 3 deg. under the most unfavorable conditions of loading—providing for the vessel landing 2 ft. off the longitudinal center line and subject to a wind pressure of 30 lbs. per sq. ft. The greatest longitudinal deflection allowable will be 1 in 3,000, with most unfavorable load, and, similarly, the greatest transverse deflection is limited to 1 in 1,800. The stability of the dock will be enormous. Carrying a 15,000-ton battleship 2 ft. above the water, the stability of the two combined will be fifteen to twenty times that of the ship floating in the water.

As designed the dock has three pontoons rigidly secured to the side walls by two horizontal rows of fastenings. The end pontoons have blunt noses with 30 ft. of the ends without buoyancy. Each pontoon has three longitudinal bulkheads, the two outer ones being water tight, while the middle one is designedly left with small openings. 'Thwartship bulkheads are worked every 10 ft., every fifth or sixth being water-tight. At the sides,

the flat floor of the pontoons is carried up 8 ft., in the shape of altars, to give increased stability. These pontoons are rigidly secured to the walls by two parallel rows of fastenings; these consist of pairs of steel T lugs riveted to the skin of the walls and pontoons, spaced every 10 ft., and of the following dimensions:

Length of flange riveted to skin	1 ft. 3 1-2 in.
" " " projecting	10 in. by 1 1-2 in.
" " upper joint	4 ft. 3 1-2 in.
" " lower joint	3 ft. 3 1-2 in.

Joints are made by fish plates 3 1-2 in. shorter than the lugs, 1 ft. 4 in. broad by 7-8 in. thick, with 2 in. holes. Steel pins, 2 in. dia., with tapered ends, are used.

The walls, while affording a certain amount of lifting power, primarily serve to give the dock stability and regulate its descent when the pontoons are submerged. They have four watertight divisions and contain the pumping plant and living quarters of the crew. On the face next the shore are built two projecting turrets to which the mooring booms are secured, with large gangway openings to admit of easy access to the floor of the dock.

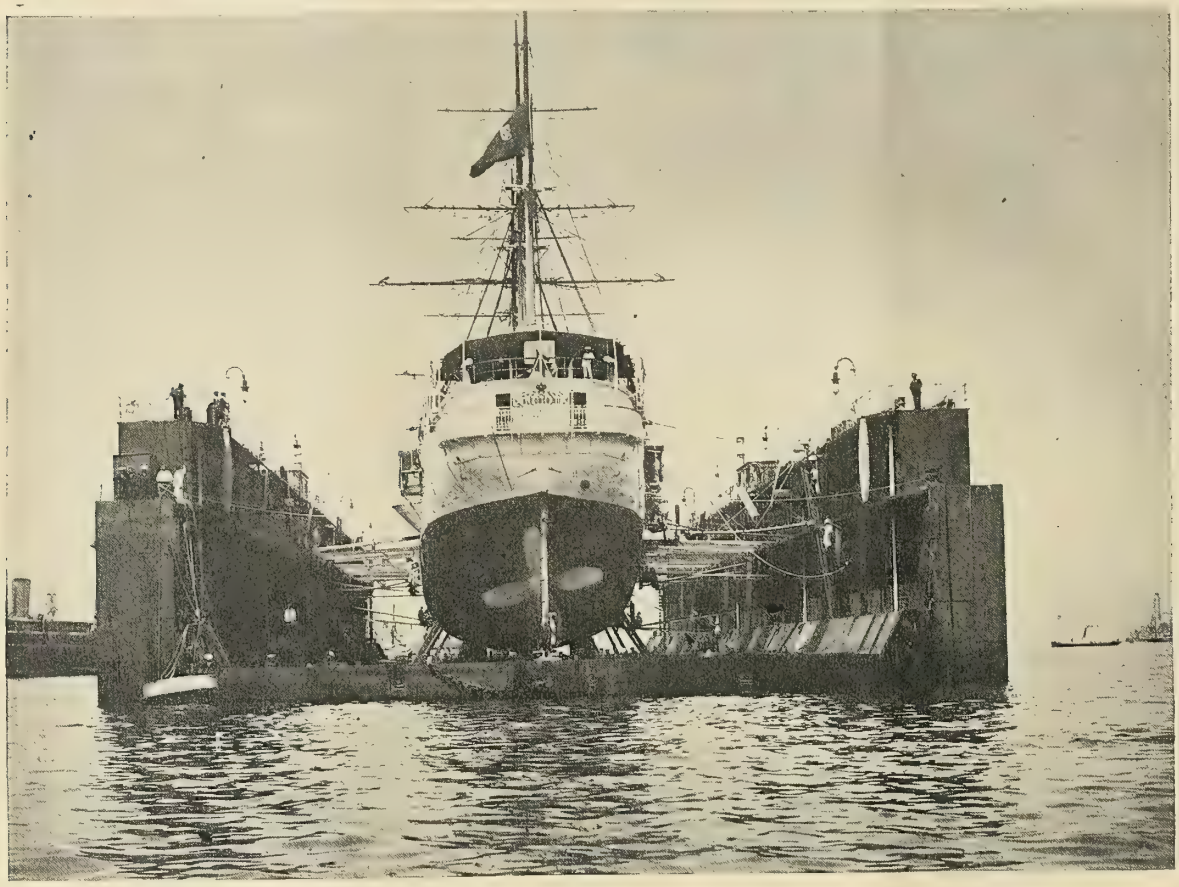
Moorings of the dock comprise four 2 in. chains, made fast to screw or mushroom anchors, planted up stream, calculated to hold against a maximum current of 6 knots, with a wind pressure of 30 lb. to the sq. ft., the ship being in or out of the water.

The dock is secured to the shore piers by a pair of hinged swinging booms, 80 ft. long, which are made fast to the turrets on the wallface and at the shore ends to heavy steel columns built in the foreshore. They are themselves fitted with tracks as gangways, and must carry a rolling load of 20 tons on two wheels. Considered as struts, they must stand push or pull of 180 tons each. In effect these booms work like a pair of parallel rulers; by veering or heaving in chain, the dock can be dropped alongside the bank or hauled out in the stream. Cross chains are provided to prevent the dock being blown upstream by the wind.

The piers are two in number, of light construction, and are carried from the pierhead to a point on the far-side of road and on a level with the top of the levee. They are fitted with tracks and must carry a rolling load of 40 tons. They are built as steel girders on light columns or screw piles, with a total length of 240 ft.

As fenders timber walling of pine 18 in. by 12 in. at and below the level of the pontoon deck is carried all around, and at the bows a separate additional fender is worked 5 ft. lower.

Adjustable bilge blocks, capable of being shifted either in or out, as well as in a longitudinal direction, are provided. In the case of a short heavy ship, a number of these blocks can be concentrated under a heavy turret. In addition strong wallings are provided at different heights along the face of the walls, so that shores may be wedged in between them and the armored belt, and thus considerably reduce the tendency this localized weight has to crush in the bilge of the ship. Four me-



FLOATING DOCK AT HAVANA, WITH SPANISH WARSHIP ON THE BLOCKS—END VIEW.

chanical centering shores are provided, also roller fenders, capstans, etc.

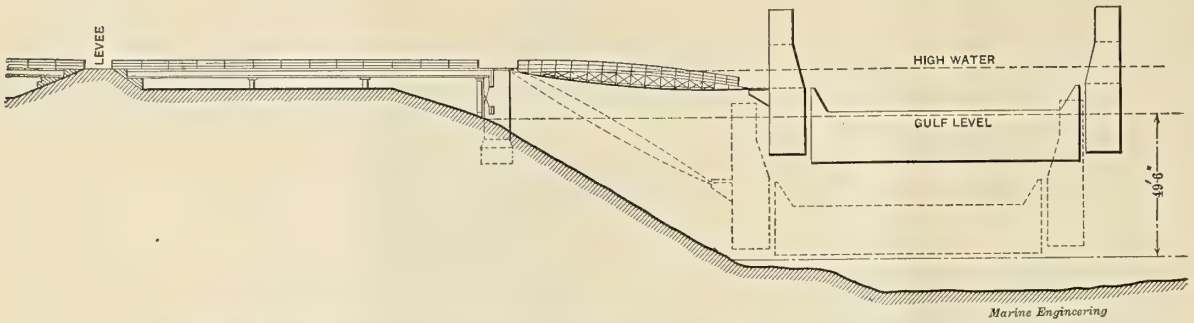
Ample pumping capacity is provided, each wall having four pumps on a main drain. The pumps are of the horizontal discharge type, and steam for their operation will be supplied by an installation of Babcock and Wilcox water tube boilers. A separate engine is provided for each pair of pumps, and a separate boiler for each engine. The steam pipes are so arranged that either engine can take steam from either boiler; each boiler, engine and pump is, therefore, duplicated in each wall; and, further, each wall duplicates the other, so that if only one boiler, engine and attendant pump remain at work the whole dock can still be lifted. A complete washing-down plant, worked by a separate Worthington pump, is provided in each wall. By the alteration of a coupling, it can be used as a drainage service for the pontoons.

The working of the whole dock is done from two central positions, one on each wall. Here are grouped in the valve house ordinary signal levers, which by rods and cranks connect to the different valves. Each valve house is in direct communication by speaking tubes with the engine rooms, so that the man in charge can manipulate every valve, both water and steam, for manœuvring the dock without quitting his station.

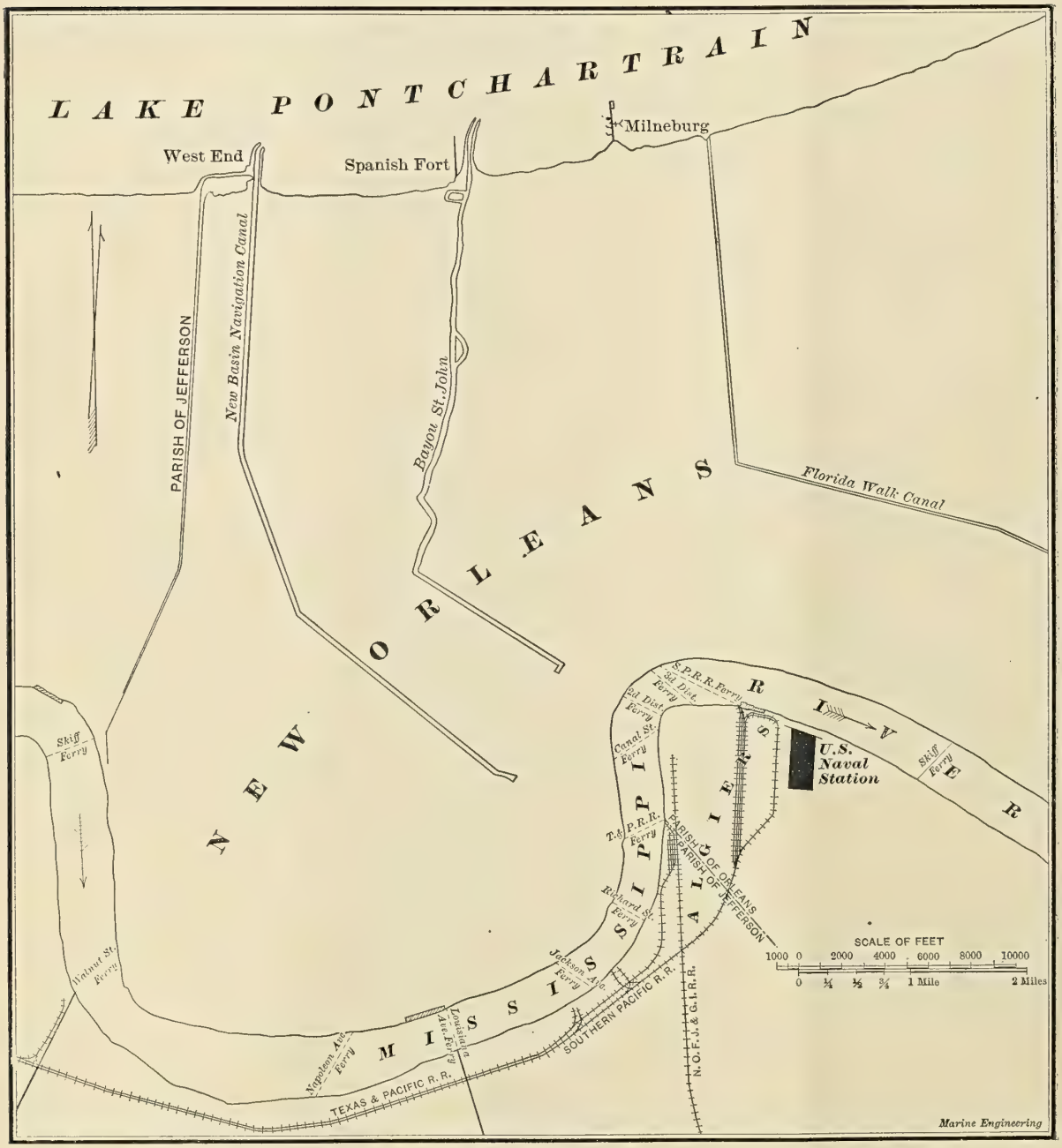
One of the most useful qualities of the Algiers dock is its "self-docking" system, by which any portion of the exterior surface can be made accessible for repairs, painting, or inspection. To reach the bottom of one of the walls, say the port one, it is only necessary to heel the dock to starboard. In the case of the pontoons, the middle one is made large enough to raise those at the ends out of water. Suppose it is desired to get at the bottom of the middle pontoon: the dock is allowed to float light; men then knock out the tapered pins of the two rows of fish plates which secure this pontoon to the side walls; then the dock is allowed to sink, the middle pontoon floating free, until the lower row of fish plates on the pontoon is level with the upper row on the walls; the pins are then driven in, the dock pumped out, and the middle pontoon is lifted clear of the water—due to the difference of height between the rows of fastenings. To undock, the reverse course is followed. The end pontoons are similarly treated. The interior of the walls and pontoons is easily accessible through numerous manholes.

Should a disabled ship draw one or two more feet than the capacity of the dock

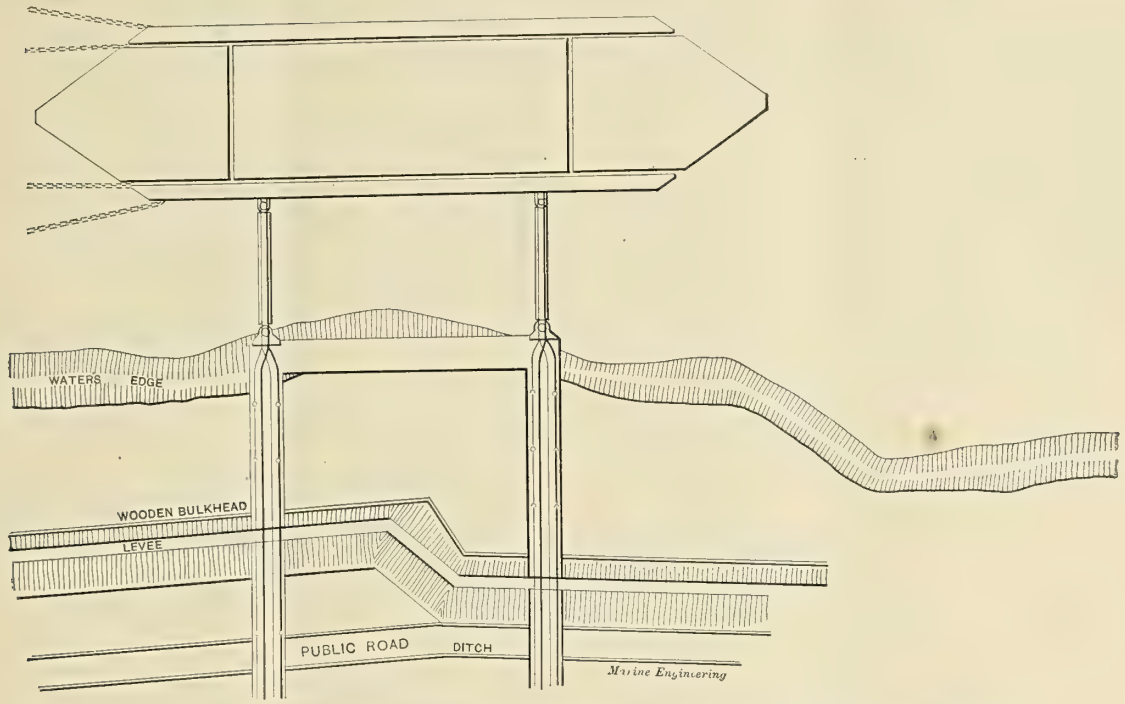
SIDE VIEW OF THE STETTIN, GERMANY, STEEL FLOATING DOCK WITH TRANSATLANTIC LINER DOCKED—SAME TYPE OF DOCK AS THAT FOR U. S. STATION, ALGIERS, LA.



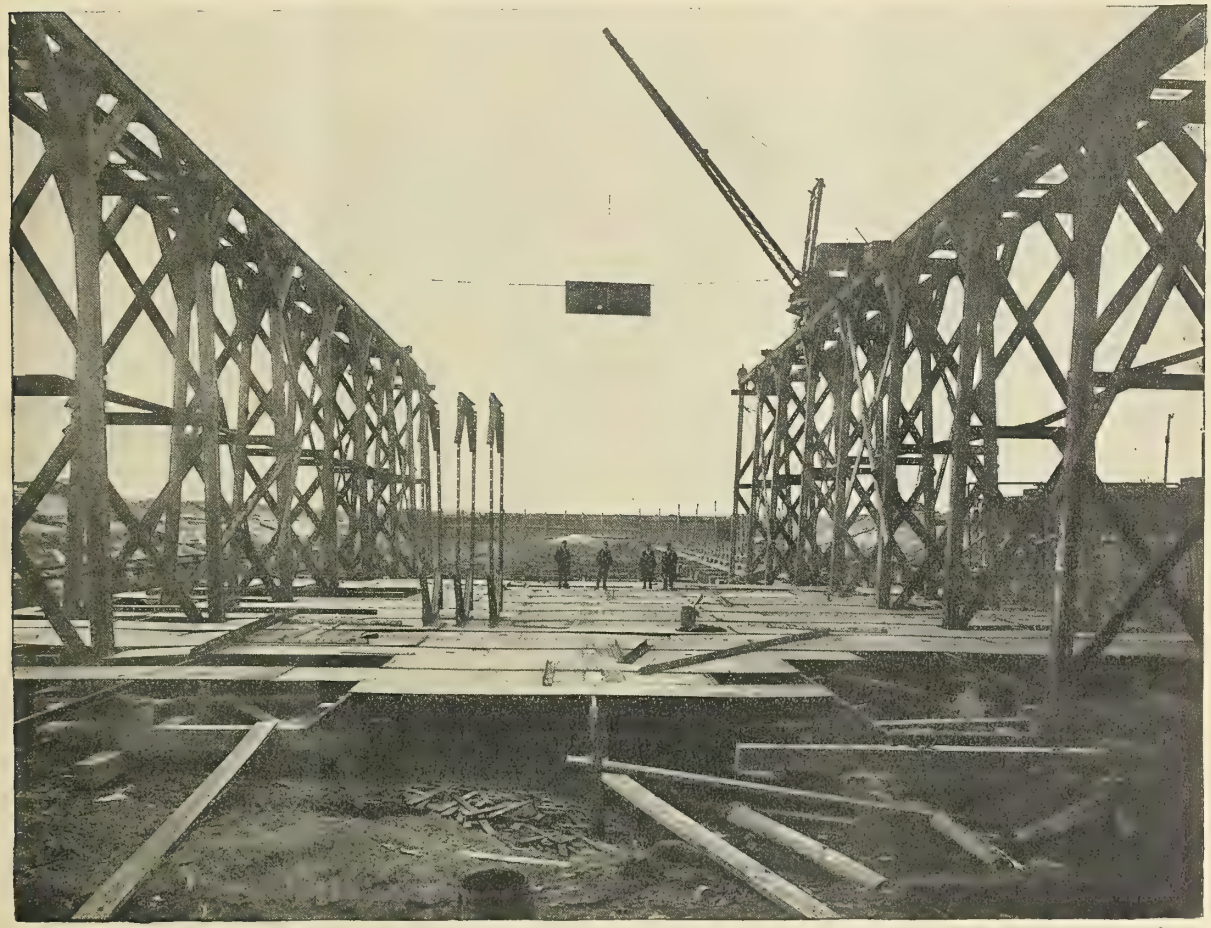
SKETCH SHOWING CONTOUR OF BANK AND RIVER BED AT DOCK ANCHORAGE IN MISSISSIPPI RIVER.



SKETCH MAP SHOWING LOCATION OF U. S. NAVAL STATION AT ALGIERS, LA., AND SURROUNDINGS.



PLAN SHOWING SHORE CONNECTIONS OF FLOATING DOCK AND RIVER BANK AT ALGIERS, LA.



LAYING DOWN THE STEEL DRY DOCK AT SPARROWS' POINT YARD—A RECENT PHOTOGRAPH.

permits, the dockmaster would not hesitate to sink the dock the extra depth, as the walls have a minimum freeboard of 4 ft. 9 in. Also, should a ship, from any cause, have a list, the dock could be given the same list within limits, the ship taken in, and the two then brought to an even keel.

Upon securing the contract for the construction of the Algiers dock the Maryland Steel Co. made extensive preparations for handling the work accurately and expeditiously. A portion of the shipyard at Sparrow's Point was fenced in as a dock construction department, and the work placed in charge of S. Anderson. A machine shop has been erected and fully equipped with all the necessary machinery. Tracks have been laid and pipes for the compressed air used in riveting. The berth itself is a huge hole scooped out of the foreshore, with the dredged material thrown up to form a coffer dam. In this berth a platform of heavy timbers has been built, and running down either side of its center line are two trestles carrying the tracks for traveling cranes, which latter will place in position every plate and angle used. It is proposed to erect those frames of the walls and pontoons carrying the joint lugs, put in the fish plates, insert the pins, and make the joint, before the side plating, stringers, decks, etc., are riveted up. The dock will therefore be built round these joints, which form, so to speak, a base from which everything will be faired. When the dock is completed, the water will be let in and the dock floated without undergoing any of the stresses due to launching from ways.

A large amount of material has been received and machined ready for erection and the actual work of construction was commenced last month. With the facilities at command, it is hoped to have the dock ready to tow to the Gulf in about eight months.

Our frontispiece shows the new dock as it will appear when constructed and with a battleship docked, the drawing has been made in perspective to show more clearly the method of docking. The drawings published with this description show accurately the general construction of the dock and the approaches, and a map of the district shows the location of the naval reservation with respect to the immediate surroundings on the Mississippi. As is well known the flow of this river is subject to great fluctuations, as it drains such an enormous territory. The stages of the Mississippi River at New Orleans, as determined by the Canal Street gauge, under the supervision of the U. S. Department of Agriculture, are as follows:

Zero of guage is 2.53 ft. below mean gulf level.
Low water of December 30, 1876, reads zero.
High water of April 16, 1874, reads 16.2 ft.
High water of May, 1897, reads 19.5 ft.
Danger line changed from 13 ft. to 16 ft. on March 15, 1897.

In discussing this dock it is of much interest to consider the large floating docks at Havana and Stettin, which were also designed comparatively recently by Clark & Stanfield of London. The accompanying reproductions of photographs show both these docks in use, the Stettin dock with a transatlantic liner on the blocks undergoing alterations, and the Havana dock, shown endwise, after lifting a Spanish cruiser. The principal dimensions of the three docks are given comparatively in the following table:

COMPARATIVE DIMENSIONS HAVANA, STETTIN AND ALGIERS STEEL FLOATING DOCKS.

Dimensions, etc.	*Spanish Naval.*	*Stettin Commercial.*	*Algiers Naval.*
Length	450 ft.	510 ft.	525 ft.
Breadth inside	82 ft.	82 ft.	100 ft.
Water on sill	27 ft. 6 in.	24 ft.	28 ft.
No. of pontoons	5	3	3
Cost delivered	$579,000	$443,000	$810,000
Weight	4,400 tons	4,510 tons	6,100 tons
Power	10,000 tons	11,000 tons	18,000 tons

Both the Havana and Stettin docks were built by C. S. Swan and Hunter on the east coast of England.

S.S. Deutschland.—At the yard of the Vulcan Company at Stettin, Germany, the new Hamburg-American twin screw S.S. *Deutschland* was launched last month in the presence of the German Emperor and members of the Government. The new vessel follows next after the *Oceanic* in point of size of ships now afloat and exceeds her very considerably in the matter of speed. Her dimensions are: Length, 662 ft. 6. in.; beam, 67 ft. 6 in.; depth, 44 ft.; gross tonnage, 16,000 tons; load displacement, 23,000 tons. With 33,000 I.H.P. the new boat is expected to develop a rate of speed of 23 knots at sea. The new steamship will have six decks extending the entire length and will have a number of special accommodations for cabin passengers, such as a play room for children, a passengers' gymnasium and a drill room on the promenade deck. The machinery of the *Deutschland* will include main engines of the quadruple expansion type, each having six cylinders: (2) H. P. 36 5-8 in. dia., (1) I.P. 73 1-2 in. dia., (1) second I.P. 104 in. dia., and (2) L.P. 106 3-8 in. dia., and stroke 72 3-4 in. Sixteen cylindrical return tube boilers will be fitted with a total of 112 furnaces. It is understood that the North German Lloyd Co. has ordered a similar ship from the builders, work upon which is to be commenced without delay.

Rescue at Sea.—When the Atlantic transport liner *Georgian* arrived in New York last month from London she had on board 35 persons, men, women and children, who were taken off the steamer *Ella* in mid-ocean. The rescue was made in a heavy sea at great risk to boat's crew of the liner. December 30 last the *Ella* left Perth Amboy, N. J., for Halifax, N. S., with 1,600 tons of coal. Captain Strange was accompanied by his wife and family. For several days after leaving port the collier met with terrific seas which battered and flooded the vessel, finally drowning out the fires. Signals of distress were answered one night by the *Georgian*, and with daylight the effort to save those on the *Ella* was made. A boat commanded by First Officer Field of the *Georgian* took off those on the *Ella* by mean of lines. The *Ella* was a steel vessel of 2,100 gross tons, formerly named the *Abydes*, and was owned in Germany. She was under charter to the Munson Line and had been engaged previously in the West Indian fruit trade.

An oil tank steamer supposed to be the *Helgoland* was wrecked in St. Mary's Bay, New Foundland, January 11, and all on board lost. All efforts to reach the vessel were ineffectual for several days after she struck, and when boats were able to reach the scene of the wreck the vessel was submerged. Many notable wrecks have occurred in that vicinity.

TACTICAL CONSIDERATIONS INVOLVED IN THE DESIGN OF THE TORPEDO-BOAT.*

BY LIEUT. A. P. NIBLACK, U. S. N.

Up to a very recent period there were a few large firms in Europe which had practically a monopoly in torpedo-boat construction, and which, in a measure, set the fashions, and ordained the types. To-day, however, both in Europe and the United States, almost any ship-yard or marine engineering firm, without traditions or previous experience, seems willing to take contracts either on plans or designs of its own or on those furnished by the Governments interested. Owing to this breaking away from old traditions and to the enormous advances made in naval construction and marine engineering, we find a resultant uncertainty as to just what is the best type of torpedo-boat. The best means of approaching the question would seem logically to be through a study of its weapon, the torpedo, regarded as the only excuse for the existence of the boat.

An automobile torpedo, launched over water from a rapidly moving and oscillating platform, encounters many variable impulses tending to deflect it from its normal course. The wrong angle of incidence of the torpedo in striking the water may give too deep or too shoal an initial dive, or deflect the torpedo laterally. Moreover, each torpedo has its nice adjustments and peculiarities, which must be learned by trial runs, so that, in general, it may be stated that much practice must be had with a given boat and with each individual torpedo to insure the chances of hitting, when the torpedo-boat has survived the many perils which beset it in getting within striking distance.

It may be stated, roughly, that the highest development of the present type of torpedo is one about 16 ft. long, 18 in. dia., and carrying a charge equivalent to 110 lbs. dry gun-cotton. The highest pressure used in the air flasks to operate the engines is 1,500 lbs. per sq. in., giving a speed of from 30 to 32 knots at 400 yards, 28 to 30 knots for 800 yards, and 26 knots for 1,000 yards. There are, of course, innumerable sizes, shapes, and variations. Some carry twice the above weight of charge. Distance and speed are largely matters of pressure and size of air flask. Some unusually long ones, for coast defense, run as high as 30 knots for 1,000 yards and 24 knots for 2,000, but, for torpedo-boats, the above length of 16 ft. and diameter of 18 in. is about the limit for convenient handling, and for weights of mounts and accessories, as the weights increase unduly for small increments in dimensions.

The torpedo is not a delicate instrument, and, after seeing many trials under varying conditions, one comes to feel that it is almost animate; but, for all that, there is a popular mistrust of its ultimate value as a weapon, in spite of what its advocates claim for it; and yet, curiously enough, the world is not yet alive to the fact that a complete revolution has taken place in the status of the torpedo by recent inventions and improvements. It now has a secure and permanent place in naval warfare, and it only remains to accept the fact.

The first improvement is the application of the principle of the gyroscope to the steering rudders of the torpedo, and the second is the perfection of apparatus that will safely and accurately launch torpedoes from the under-water broadside of a rapidly moving ship. The latter practically does away with above-water discharge in large ships, and the former has doubled the accuracy of fire.

In the Howell torpedo, the invention of Rear Admiral J. A. Howell, U. S. N., the motive power is a fly-wheel spun up previous to launching, and the remarkable results in directive force and persistence of the torpedo by the gyroscopic action of the fly-wheel has led to its adoption in a miniature form as a separate attachment to an ordinary torpedo, involving no radical changes in design, since it takes the place of a certain amount of ballast and merely adds a pair of rudders and a few connections. The first practical design of this was by an Austrian, named Obry, and Whitehead and Company acquired the sole rights. The question of infringement of the Howell patents has not deterred others, and there is a successful one in Germany.

We had a naval commission at Fiume in November, 1896, to witness the first exhibition of the workings of the Obry attachment, and, later, a trial in the United States, which showed that it was "an excellent practical apparatus sufficiently robust for the conditions of use, not difficult of adjustment, and not requiring frequent adjustment, and its capacity for steering the torpedo in the course indicated by the direction of the axis of the torpedo at the moment of launching or in a course parallel thereto, after the first unavoidable deflections due to unfavorable conditions of launching, was such as to improve the performance of the torpedo 100 per cent."

One naval commission at Fiume made the following trials successfully, not once, but many times: Ordinarily the gear does not start up until the moment of launching of the torpedo, which act puts in operation a tightly wound clock spring, which, in turn, spins up the gyroscope and keeps it going. A torpedo-boat, at high speed, steaming past a target at some 600 yards distance, pointed its tube at the target, and, by a special arrangement, released the spring. The tube was then turned off the target about 45 deg. and the torpedo launched. The gyroscope, true to its principle, brought the torpedo back *parallel* to the original plane in which it was started in operation, and excellent targets were made. The course of the torpedo thus fired is a horizontal wave.

At Fiume, using the attachment, excellent results are obtained from fixed under-water launching at 1,000 yards, and, with improvements in air flasks as to volume and pressure, we may expect to see the effective range of torpedoes in naval warfare regarded as 800 yards, instead of being limited, as now, to 500 yards or less. Torpedoes, which are erratic, ordinarily, to the point of rejection, are fired successfully right along, using the Obry gear, and, in a recent trial, torpedoes were fired from an under-water broadside tube of a ship steaming 16 knots, and made excellent targets, using the attachment, although the permanent angle of deflection of the torpedo, due to the method of launching, was not known within 10 deg. As the Obry gear and the method of under-water discharge from ships have both been adopted in our navy, we may assume that in the future we may count tactically on these latest inventions being used, at least in large ships.

*Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York.

If we consider the conditions under which a torpedo-boat may be reasonably expected to be effective against a ship or the ships of the enemy, we will find that an attack, to have a reasonable chance, must be a surprise. Hence darkness, fog, mist, snow, and rain are the favoring conditions. Heavy rains are particularly favorable since, for the defence, the eyes of lookouts are punished severely by the water, it is hard to keep men constantly at the battery, the searchlight is more than useless, sights are blurred, and outside noise is deadened by the fall of rain. Attacks are made in groups of boats, and it is this which we lose sight of in the United States. A single boat would only attack as a forlorn hope, and under most extraordinary circumstances. All torpedo-boat attack must be in groups, and must be, as in polo or football, or any other similar game, a question of "team work," of "interference," of strategy, head, and nerve. Of all things, it is a question of system. A ship or a squadron attacked simultaneously from various directions must destroy or drive off all the attacking boats or take the consequences. Feints will naturally be made. The first boat or boats discovered will advance fearlessly, dropping and scattering small incandescent buoys to disconcert the aim and create the illusion of numbers, and, if so fitted, use their searchlight. Under strong excitement it is peculiarly human to yield to the temptation of shooting at a light without reasoning. Meanwhile, some one or more boats will get in their torpedoes from an unexpected quarter. Numerous tests at manœuvres in many navies have shown that it is astounding how often torpedo-boats get in *without being seen* and when *expected*. Some people go so far as to say that the searchlight beam is the safest path of approach, and, in one navy, they practice running in it so as to get accustomed to the glare and to judge distances.

In approaching to the attack, previous to discovery, reduced speed must be used so as to avoid white bow waves, smoke, and flame, and that peculiar and far-sounding hum which accompanies fast-running machinery. Once discovered, or once within striking distance, high speed becomes important, but it takes some little time to attain it after having once slowed. As between a speed of 20 and one of 30 knots the time it takes to cover 1,000 yards is only as 90 seconds to 60 seconds. Can the 30-knot boat pass from 20 to 30 knots in 30 seconds? If you can build three boats of 22 knots for what two of 30 knots cost, and if the greater the number of attacking boats the better the chances, is it not wise to forego phenomenal speed? This craze for great speed is illogical and tactically it is indefensible. Back of it is generally an advertisement for somebody. People who handle torpedo-boats have never sanctioned it. What they do ask is that boats be built in groups on identical designs, and that every reasonable effort be made to standardize fittings. As long as fittings are standardized, we may improve groups progressively from year to year as experience dictates.

We are boxing the compass in our torpedo-boat building programme, and there seems to be no known relation between horse-power and displacement. The real excuse for the boats is that they shall carry torpedoes. Let us look abroad and learn lessons. To say that we have not yet had experience enough to warrant us in standardizing fittings is begging the question. From a military standpoint the standardizing is more important than that the fittings should be the latest complicated invention, largely experimental. It is a simple matter to decide, for instance, that all boats shall have the same size and type of water-tight doors, hatches, conning towers, hatch covers, manholes, bunker plates, anchors, cables, winches, steering engines, annunciators, telltales, galleys, deck chests, navigation supplies, fenders, reels, compasses, torpedo-cranes, awnings, whistles, sirens, bunks, mess tables, etc. This would do to start with, but the logical culmination of the idea is to build the boats in groups with interchangeable parts.

Before taking up the question of the proper relation between tonnage and horse-power for first-class torpedo-boats, let us look at some of the questions of detail, as illustrated by foreign practice. We regard it as essential, apparently, that a torpedo-boat of considerable size shall have twin screws. Great Britain has nearly 100 first-class torpedo-boats, varying in tonnage up to 130 tons, and of which only one has twin screws. Austria has 30 of from 78 to 134 tons, all single screw. In Italy twin screws are used above 100 tons displacement, and single screws for boats of less tonnage. In France, with some 225 or more torpedo-boats of from 75 to 150 tons displacement, all have twin screws; but, below 75 tons, single. In Russia, of the first-class boats of from 75 to 140 tons, only one group of seven has twin screws, although there are several other groups building in which this is also true. The vast majority are, however, single screw. In the Baltic countries, Germany, Denmark, Norway, and Sweden, practically all boats are single screw and have bow torpedo tubes. Nearly all the boats built by Schichau, of Elbing, Germany, are single screw, and this firm has built about half of the torpedo-boats of the world, but these boats have a bow rudder which may be raised or lowered at will, and which, when in operation, increases the manœuvring power very much. This device is equally important in many of our twin-screw boats, since the pivot, in turning, is almost at the fore foot, and turning is best accomplished by throwing the stern about with the screws. A bow rudder would shift the pivot to about midships, and improve the manœuvring power considerably.

As to bow torpedo tubes, we regard them as a folly, yet most of the boats of the world have them, and there is not, in Germany, a fighting vessel of any type, built or building, which does not have a bow tube either above or below the snout of the ram, below being the accepted position now.

As to the argument as regards single *vs.* twin screws, the former with bow rudders handle quite as well as the latter without, and it is claimed for the single screw that: (1) There is a great saving in oil with only one engine, and, when we consider that with two it takes about twenty-five gallons a day, this is important. (2) It takes fewer men to look out for one engine, the saving being at least two or three. (3) There are fewer moving parts, and, therefore, less chance of breakdown, while, at the same time, sufficient horse-power can be developed to give reasonable speed. (4) The weight and space of machinery is less, and greater strength can be afforded. After all, reliability of machinery is a matter of design, of material, and of high-class workman-

ship, and single screws have quite as much to commend them as twin, provided sufficient horse-power can be developed. One of the great drawbacks to single screws is that their draft of water is greater, especially for boats with a skeg, or keel support for the heel of rudder, although in some of the Thornycroft and Yarrow boats there are no supports for the rudder, and thus some inches of draft are saved.

As torpedo-boats abroad are frankly intended to manœuvre or cruise in groups, questions of spare parts, breakdowns, shortage in supplies, etc., are not so serious, since the boats rely on one another somewhat in cases of emergency. Probably no country has developed her torpedo-boat system so thoroughly as Germany. Fully 90 per cent of her boats were built by Schichau, and the custom is to order them in groups of eight, all practically of similar design and with interchangeable parts. The tonnage has gradually increased from 85 to 140 tons, as at present. Six of these boats form a group for manœuvring purposes, so that two of the eight are kept in reserve to take the place of any that may come to grief. There are ten large division, or "D" boats, of from 250 to 380 tons displacement, and from 1,800 to 5,500 horse-power. They are each a sort of flagship, or "mother" boat, for each group of six smaller ones, and accompany it everywhere. This division, or "D" boat, carries the heavier spare parts for the six accompanying boats, such as cylinder-heads, piston-rods, propellers, and a reserve supply of stores and fittings. Each "division" has its headquarters at a certain navy yard and has a group of small storehouses at the water front, one for each boat, including the "D" boat and the two in reserve. When a whole division is in the second reserve all the stores of each boat are in its own storehouse, and the group of boats is tied up near the group of storehouses. Any deficiencies in stores or fittings are made up from the large central torpedo storehouse, where all articles are standardized. In the winter the boats in reserve are kept at a uniform temperature by means of steam coils, connected with the shore by piping. Only when repairs are needed are boats hauled out, so that the division may always be ready to be put into commission for trials in 24 hours and ready for war in 48 hours. If in drills, or cruising, a boat is injured, it is astonishing to see how quickly a spare boat of the group is forthcoming, and ready with the crew of the injured boat. Boats in the second reserve are looked out for by the navy-yard force, and a vessel under repair is always in the second reserve.

As to boilers, the locomotive type has at last disappeared in newer boats. It retained its hold as long as it did through its adaptability for burning liquid fuel. The introduction of water-tube boilers has rendered it necessary to experiment somewhat as to the types best suited for burning petroleum refuse. In Germany they use, very largely, a German product called earth oil, unfitted for refinement, and they burn it on the Italian system (cuneberti), but principally as an auxiliary fuel for high speeds and for starting fires quickly. The Russian refuse oil is used in Italy, and it is stored in tanks at the principal dock-yards, there being on hand a large reserve for war. Practically, all of their torpedo-boats and fully thirty of their largest men-of-war use liquid fuel either entirely or as auxiliary to coal. In Russia experimenting goes on apace. Our country, of all others, might well adopt liquid fuel, although the purity of the ordinary petroleum and lack of residue makes it necessary to conduct experiments. Its evaporative efficiency as compared with coal is as 2.27 to 1. For the same storage capacity it adds 60 per cent to the radius of action of a boat; it can be delivered at sea from tank steamers in a few hours and in bad weather; it is absolutely free from danger of explosion and ignition, which coal is not; the amount used can be regulated accurately; forced draught does not require extra work on the part of any one; there is no need to transport fuel long distances as with coal; it prevents rust in bunkers; if a bunker is pierced the petroleum flows out only to the level of the water; it maintains steam more economically at anchor and in running slowly; the boiler does not choke; there are no ashes to hoist; it is easier on the boilers; it does away with coal passers; a water-tender can also fire; and above all it enables us to get steam quicker and to vary the pressure more easily at will. There is one thing to be considered, and that is that the compressed-air method of feeding commends itself in preference to the steam jet, because in the first place the air-compressing machinery must be in every boat anyway, and in the second place, the radius of action of a torpedo-boat is absolutely limited by her fresh-water supply, and not so much, as supposed, by fuel, although, of course, it takes fuel to distil water. It is in this question of fresh-water tanks and storage capacity that all these fancy yachts and phenomenal torpedo-boats prove failures for hard sea service.

One of the most important questions to be asked about a torpedo-boat outside of the motive power is as to the capacity of her distillers and tanks. Moderate, reliable sea speed coupled with large capacity for carrying and distilling fresh water is the fundamental requirement. Distilling ships to accompany ships operating from a distant base are a modern naval necessity. Fresh water represents time and coal, and is not so readily obtained as coal, at least as a commercial article. With liquid fuel, a navy will have to provide itself with tank steamers for both fuel and water, more especially if the method of burning it is by the use of steam spray or jet, but even using the compressed air spray the amount of water required to make up feed-water is astonishing.

All this suggests the question, "What are the desirable characteristics of a first-class sea-going torpedo-boat?" The answer here given is: (1) It should be as small as is consistent with seaworthiness, so as to offer as small a target and be as little visible as possible, and, at the same time, should offer a reasonably stable platform for its torpedo tubes. (2) It should be designed to have as small a bow wave as possible; its machinery should be as nearly noiseless as practicable; and it should not show flames or smoke from the stacks. (3) It should have a large fresh-water tank capacity and be fitted with two smaller evaporators and distillers in preference to one larger one. (4) It should have a reasonable bunker capacity. If for coal, the design should have in view the future use of liquid fuel. (5) The efficiency of the boat depending so largely upon the physical condition of the crew, habitability should receive due consideration in the design. (6) Speed is not essential, although desirable, but a moderate reliable sea speed, obtained without forcing and without noise, flame, and vibration should be striven for.

The use of liquid fuel best avoids the question of flames and smoke from the stack, and noisy machinery and bow waves are best avoided by moderate speed secured by reliable machinery and boilers of ample power normally. A speed of 22-23 knots on a maximum displacement of 110 tons is here suggested for sea-going torpedo-boats, and 45 tons for harbor-defense boats, or boats of the second class. We have in the *Morris* and the *Talbot*, built by the Herreshoffs, a near approach to the ideal boats of the first and second class. Boats above 110 tons are too large to go through the systems of canals in the interior waterway which connects New York with South Carolina. On the Pacific Coast, except about Puget Sound, all of the harbors are practically bar-bound in bad weather, and first-class torpedo-boats will not prove as desirable as second-class ones, which are intended only for local harbor defense. Since the coast is so remote from any possible enemy, even a torpedo-boat is a luxury, although a number of sea-going torpedo boats and destroyers will be required on the Pacific Coast for drill and training purposes, and in Puget Sound for service.

FIRST-CLASS SEA-GOING TORPEDO-BOATS OF SEVERAL NAVIES.

Country.	Date.	Where or by whom built.	Length (ft.).	Beam (ft.).	Draught (ft.).	Displacement (tons).	I. H. P.	Number Screws.	Extreme speed (knots).	Complement.	Coal (tons).
Austria	'95	Yarrow	147.5	14.7	6	107	2200	1	24	26	30
Denmark	'93	Copenhagen	140	14.3	7	114	1300	1	22	24	25
France	'92	Gruville	147.5	14.5	5	114	1550	2	24	34	20
Germany	'92	Schichau	144.4	16.5	7	110	1500	1	24	24	30
Great Britain	'87	Yarrow	135	14	6	105	1540	1	23	21	30
Italy	'97	Italy	135	14	5.3	110	1600	2	25	20	30
Russia	'91	Russia	128	15.7	6.9	98	1250	1	21	13	17
United States	'96	Herreshoff	139	15	4.1	103	1750	2	22.5	26	28
Approximate average	'93		140	14.8	6.0	108	1560	1.4	23.2	23	24

The foregoing table shows the principal characteristics of a certain number of sea-going torpedo-boats of several countries, selected to correspond to a displacement of about 100 tons, but not as representing the standard type, although it may reasonably be assumed that any given boat represents the best at a given date of building. The "approximate average" is, of course, somewhat misleading, but is suggestive. As regards twin *vs.* single screws, it does not prove much. Both the draft and speed of the *Morris* are greater than given officially, although draft up to a certain point is a matter of little importance, since it is unsafe to fire a torpedo in less than 30 ft. of water, owing to the possible initial dive. For canals 6 ft. is not too much. It is estimated that for a boat of about 110 tons displacement it will require about 1,550 horse-power to drive her 23 knots, and 3,100 horse-power for 30 knots; in other words, about twice as much. Of course a great deal depends upon the design of the boat.

Since 1893 the size of torpedo-boats has increased very considerably, as in France, where the latest type is 150 tons and 4,200 horse-power, with 30 knots speed; Germany, 140 tons displacement, 2,500 horse-power, and 25 knots; and Italy, 150 tons, 2,700 horse-power, and 25 knots.

Just before the war with Spain, the United States bought at Schichau's, Elbing, torpedo-boat No. 450, now called the *Somers*. She is a single-screw boat of 143 tons displacement, 1,700 horse power, and a speed of 23 knots, and was built, in 1893, on the same lines as a group of other boats for the German navy, but with a quadruple-expansion instead of a triple-expansion engine. As there was no advantage demonstrated in the departure from the standard triple-expansion type, the German government declined to purchase her, and she was later offered to us. I personally recommended her purchase on the ground that whether or not she could be gotten across in time to be of service in case of war, she was a model boat, in many respects, since she was fitted with all the articles so carefully and systematically standardized through all these years by the German navy, and there is not a detail in her that has not its lesson for us. Far from being a failure, as many believe who talk and never think, I personally conducted her trials, which were satisfactory, and would consider it an honor to command her.

In the torpedo-boat discussion last year the following remarks were made [Transactions, Vol. VI, p. 66] which so nearly represent the exact opposite of what is here advocated that they are worth quoting:—"I believe we are very far from the final results under the extreme speeds, and as to advocating a slower boat than our enemy has—why, it will undoubtedly place us in a hazardous position. * * * I believe there is plenty of ability in the country to develop men who can handle the more refined type of torpedo-boats, and I believe that it should be invited and should not be condemned any more than the use of the chronometer should. Without careful treatment it is certainly useless, and

the torpedo-boat is undoubtedly recognized as being a refined machine." There is a good deal of misconception in all this. A fleet operating on an enemy's coast has with it torpedo-boat destroyers. Their base is the fleet; their purpose, to hunt out and destroy the torpedo-boats of the enemy. To say that it is hazardous to have slower torpedo-boats than one's enemy is to imply that torpedo-boats attack torpedo-boats. The technical opinion is that torpedo-boats operate from a port as a base. If two hostile ports are adjacent, then it might mean something. Of course, a destroyer can overtake a torpedo-boat, or is designed to do so. In a heavy sea an 18-knot cruiser might overtake a 30-knot destroyer. As regards a torpedo-boat being a "refined machine," every effort should be made to get it out of that category. Of course, a torpedo-boat needs skillful and intelligent handling, but the cavalry does not use race horses, and high-stepping hackneys do not make good polo ponies.

In conclusion, let it be understood that real progress is just as admissible with standardized fittings as with chaos. We can also learn several lessons from recent events. The *Oregon* and the *Iowa* gave a beautiful object lesson when they cut loose from a base in New York and reached, the one San Francisco, Cal., and the other, Manila, P. I., without having to rely on any supplies other than those they had in the auxiliaries accompanying them. Lieutenant Commander W. W. Kimball, U. S. N., has proposed that we adopt for sea-going torpedo-boats a similar scheme; that a certain number of boats in a group have as a base a large depot steamer to carry coal, liquid fuel, oil, water, waste, compressed air, spare parts, medical officers, relief officers and men, stores, supplies, repair shops, etc. This will enable us to shift the base from point to point, and make a fewer number of torpedo-boats cover a wider stretch of coast. With such a long coast line as we have, we can never afford to have all the torpedo-boats required. This would mean sea-going torpedo-boats for coast defense, and second-class boats for harbor defense, which is technically correct. Torpedo-boat destroyers, operating from a fleet as a base, would accompany said fleet wherever required to assist in protecting it from attack by the torpedo-boats of the enemy; in other words, in operations on the enemy's own coast. This view of the use of destroyers and first and second-class torpedo-boats is in conformity with modern tactical and strategical ideas.

A 500 FT. LAKE STEAMER.—At the Lorain, O., shipyard the steel lake freight steamer *John W. Gates* was launched last month. The new vessel is one of the four steamers of about 8,000 tons carrying capacity, building on the Great Lakes for the A. B. Wolvin and American Steel and Wire Co.'s interests. Her dimensions are: Length over all, 500 ft.; beam, 52 ft., and depth, moulded, 30 ft. The vessel is very strongly constructed. Her water bottom is divided into thirteen water tight compartments, and the hold into six water tight compartments by cross bulkheads. She will be fitted with quadruple expansion engines, with cylinders 16 1-2 in., 25 1-2 in., 38 1-2 in. and 60 in. dia. and 40 in. stroke, supplied with steam by Babcock & Wilcox water tube boilers. A propeller 14 ft. dia. and 15 1-2 ft. pitch will be fitted.

WORK OF THE U. S. ARMY TRANSPORT SERVICE AT SAN FRANCISCO, CAL.

Now that the transporting of a large army from the British Isles to South Africa is a matter of widespread comment among those interested in maritime affairs, and the general public, it is well to recall our recent experiences in this particular branch of sea traffic. The transportation of 40,000 troops across the Pacific to the Philippine Islands by the United States Army Transport Service at San Francisco was no easy undertaking. It necessitated the conversion of many "raw" merchant vessels into up-to-date transports adapted to all the requirements of the department; but this work, undertaken with the supervision of Colonel Oscar F. Long, U. S. A., an old campaigner and field companion of the late General Henry Lawton, was carried out with such rapidity and thoroughness as to win high praise from the authorities at Washington for the engineering talent on the Pacific coast.

That so large an army of men could be sent to the front with so little embarrassment to the War Department, and with small loss to the Government in ships, machinery, and men, is a remarkable achievement considering the available facilities. The days of departing troops have now passed, the reorganized fighting forces having been reduced one hundred per cent., and consequently the demand for mechanical skilled labor has very greatly decreased. Nothing now remains for the western division of the service to accomplish but to keep the regular fleet of transports in good repair; most of the chartered ships have been released, and only those owned by the Government will be kept on the route between San Francisco and Manila.

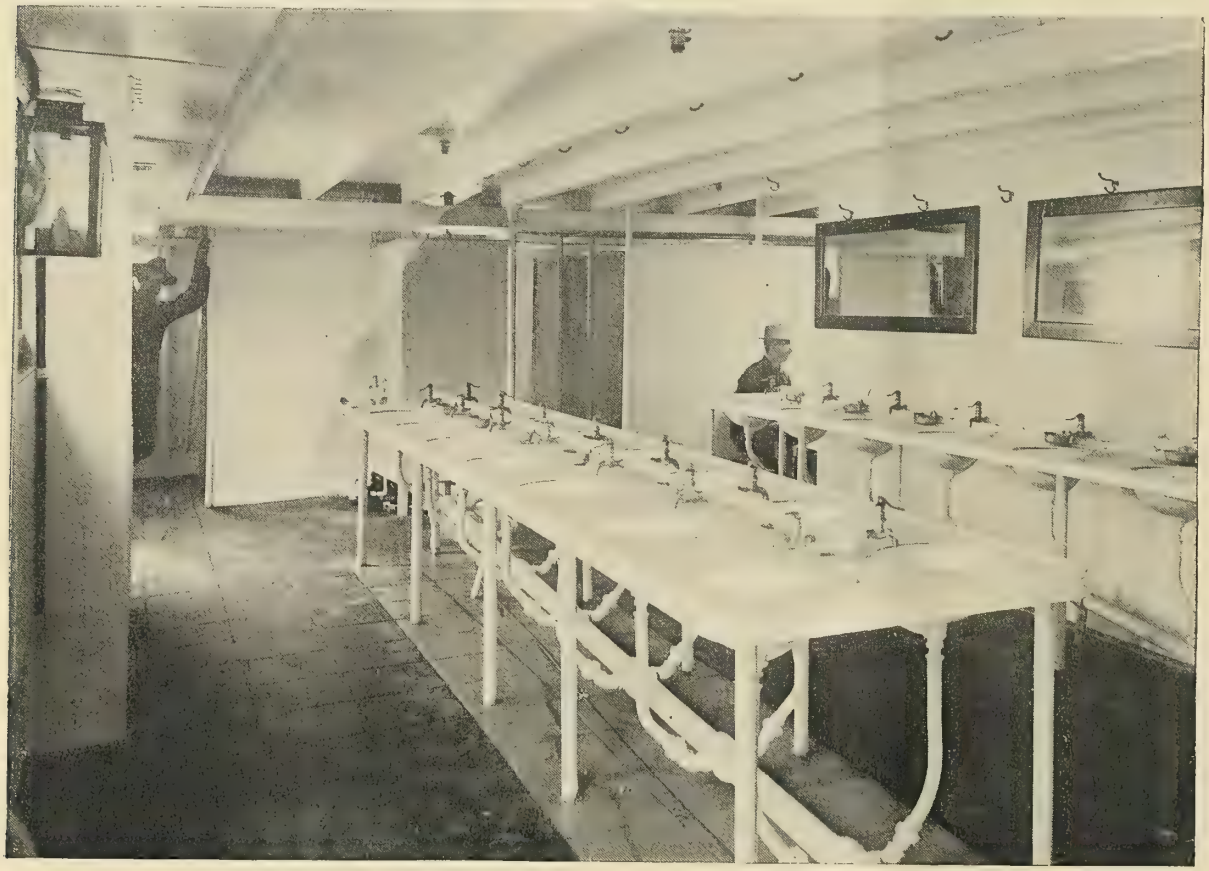
This war experience was not without its effect on the engineering interests of the Pacific coast. When it became known that the War Department intended sending large reinforcements to the front, that a great fleet of ships would be employed, and that all the vessels would require considerable remodeling, the iron works of San Francisco commenced to improve their plants and arrange to compete for the work that was sure to be offered on the Pacific coast. Several of the larger plants were, of course, already prepared to do any line of mechanical work, but there were a number of smaller shops that had not the equipment necessary for turning out a first-class job. These plants were informed that entire impartiality would be observed and that their bids would be taken into consideration with those of the greater establishments. The result was the smaller shops were enlarged and received a fair proportion of the work, though the large works got most of the extensive contracts because of their better facilities.

In order to realize what an undertaking the transport service was confronted with, it must be understood that the Government was without a sufficient number of steamers to draw upon in Pacific waters. The vessels secured were "raw" and engaged in the regular pursuits of commerce when spoken for. Many of the craft were without the ordinary equipment that might reasonably have been expected to be found on them. Operations were first commenced in May, 1898, and at that time there was not a steamer on the Pacific coast fitted for the transportation of men or stock to a port so dis-

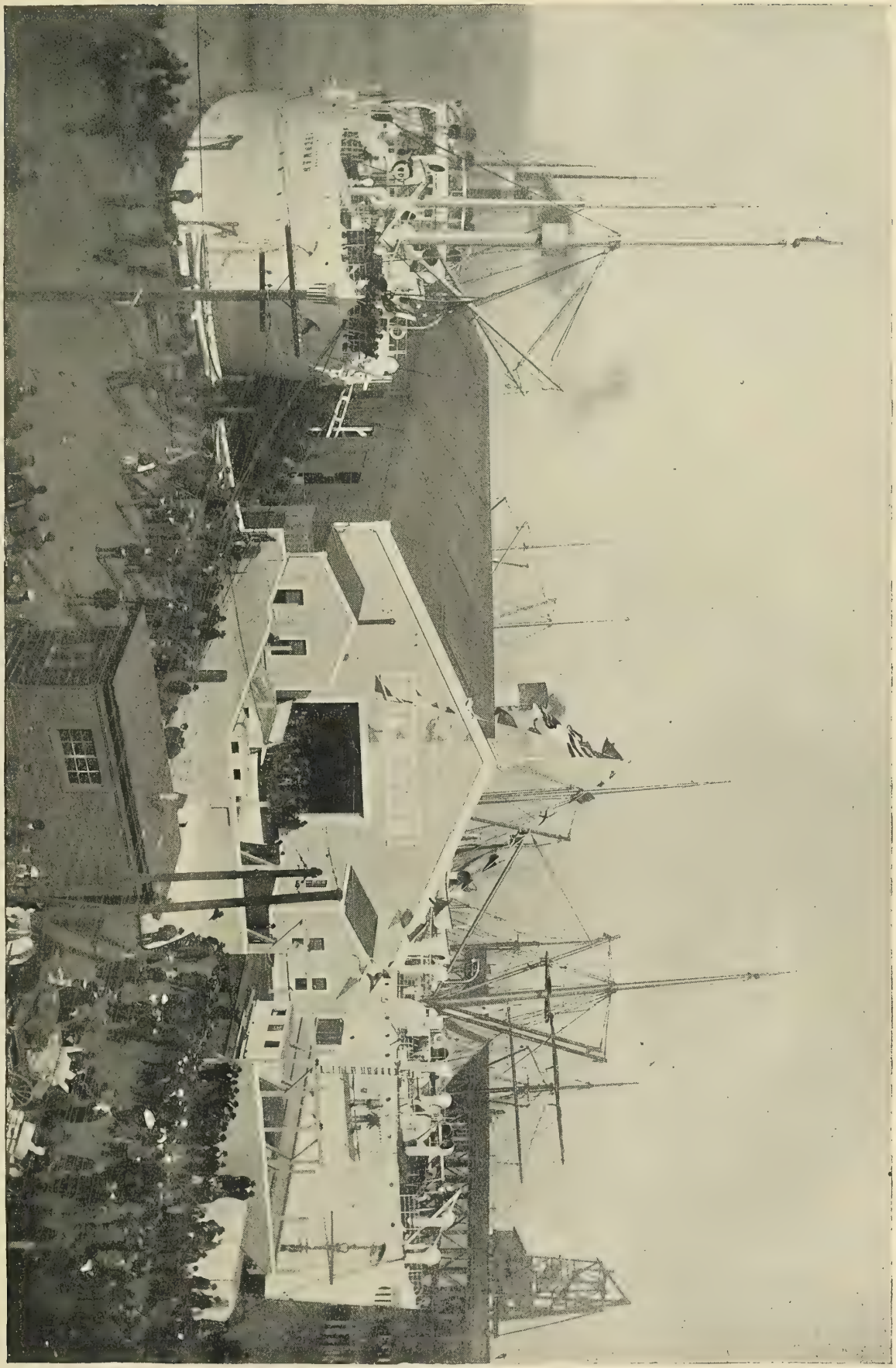
tant as Manila. The ships of the Pacific Mail Steamship Company and the Oceanic Steamship Company, together with a couple of fast steamers belonging to the Pacific Coast Steamship Company, first attracted the attention of the Government officers. A number of these had been chartered to serve in the transporting of the volunteer army, but had been turned back, stripped of all the troopship fittings and made ready for regular commercial service again. The work of remodeling them had to be done all over again, and while the workmen were engaged on these pioneers of the "second call," messages were sent to the North and to the Orient querying owners of British tramps and American coasting craft.

By the middle of June Colonel Long was relieved to find that he had enough tonnage in sight, subject to charter or purchase, to carry 25,000 men. In the meantime the regular army transports, *Warren, Sheridan, Grant, Sherman, Hancock* and others, some of which were fitted out in Atlantic coast yards, were being counted on for immediate service. These ships had already voyaged to Manila and were in need of an extensive overhauling. It was decided to make the *Hancock* a particularly fine specimen of the American transport. Features of the equipment were a large refrigerating plant, with a capacity for storing enough meat to last 1,000 men four months; a soldier's kitchen provided with all kinds of appliances for steam cooking; an armory, magazines, and specie tank, all of large capacity. About $100,000 were expended in refitting the *Hancock*. Special care was taken with the finishing of the staterooms and officers' quarters, free use being made of burled red wood, selected pine and hardwood.

When a fleet of vessels had been secured for transport service attention was directed to the preparation of these vessels for their new service. A record was established by the discharging, repairing and reloading of eighteen vessels in as many days. The repairs to the fleet included not only general overhauling of the machinery, but the tearing out and rearranging of bulkheads, and the building of frames for bunks for an average of one thousand men to each ship. It was found that many of the ships hastily purchased by the Government were fitted with practically obsolete machinery. New boilers had to be furnished for some, and all required new deckhouses, lavatories for the men and shower baths, besides the regulation soldiers' kitchens. The same class of lavatories was placed on all the ships. They were modeled after those in use on the *Sherman, Sheridan* and *Grant*, and consisted of granite ware and porcelain basins with stop-cocks and open-work plumbing placed on tile floors. Patent closets were set in all the forward and after lavatory quarters. On deck a series of zinc troughs was set near the rails and connected with hot-water pipes. These sinks were intended for the washing of soldiers' dishes, and some for general cleansing purposes. Isolation hospitals were built in the after part of the ships or on top of the after deckhouses. These usually contained a ward and operating room and staterooms for the Red



ARRANGEMENT OF SOLDIERS' LAVATORIES IN U. S. TRANSPORTS FITTED OUT AT SAN FRANCISCO, CAL.



SAILING DAY AT THE U. S. ARMY TRANSPORT WHARF AT SAN FRANCISCO, CAL.—TRANSPORTS ABOUT TO LEAVE FOR THE PHILIPPINES WITH REINFORCEMENTS.

Cross corps. Storerooms were enlarged and extra lighting apparatus put in.

The transport service was confronted with a very serious situation when so many steamers were forced on the market for coal supplies. The dealers had not a sufficient supply on hand, and any sort of fuel had to be accepted that was offered. Next came the oil trouble. Certain oils were contracted for, and when examined it was found that much was unfit for use. It contained so much grit that it wore down the bearings of the machinery, necessitating the removal of the damaged parts on the return of the transports from their first trips out. The oil contracts were relet, and very little trouble was experienced with lubricants when special inspection was made of all oils delivered.

When so many vessels had to be selected from out of a comparatively small number of available ships it was not in every case possible to get them in a thoroughly satisfactory condition. When placed in service, however, few of the vessels behaved badly. Sensational newspaper reports concerning the condition of the transport *Manauense*, which arrived out after a perilous voyage, were widely published, in which it was made to appear that the vessel was unseaworthy when sent out as a transport. An inquiry into the circumstances connected with the taking over of the vessel for Government use showed that repairs made on it were not carried out by the Government, but by the owners of the vessel, who expended about $21,000 on the work. On receiving the vessel the transport officers had fitted it with bunks for the use of 450 men, and had also put in special fittings in the cabin and general quarters. The vessel had come from the Orient to San Francisco, and had made one coast trip before being put into service as a transport. She was chartered to the Government for $500 a day. The vessel was passed by the local U. S. Inspectors of Hulls and Boilers and by Lloyd's surveyor, and she was believed to be in good, seaworthy condition when she was sent to Manila with troops. It is believed in San Francisco that the trouble with the machinery of the vessel was probably due to negligence or incompetence in the operation of the vessel, and the story that she sprang a leak is discredited. In the opinion of the engineering staff of the transport service the chief cause of trouble was in the construction of the vessel. She is of the spar deck type, and between her poop and bridge houses there is a space sufficient to hold an immense quantity of water should a heavy sea be shipped. On her voyage out the vessel was caught in a typhoon and is supposed to have shipped a number of seas and been flooded, as her freeing ports were not of a sufficient capacity to carry off the water.

The *Manauense* is an old iron screw steamer built in 1874 at Port Glasgow, Scotland. Her dimensions are: Length, 281 ft.; beam, 32 ft.; depth, 23 ft.; gross tonnage, 1,672 tons. She is fitted with compound engines, with cylinders 41 in. and 71 in. by 42 in. stroke.

From May, 1898, to date the transport officers have handled 126 ships, almost all of which needed repairs of one sort or another. The engineering work was in charge of Superintending Engineer J. H. Matthews and his assistant, Mr. Humphries, working under the direction of Colonel Long in command of the service.

S. Y. Margarita for A. J. Drexel.

The accompanying drawings show the outlines and accommodations of the steam yacht *Margarita*, now building at the Scott Yard, Greenock, on the Clyde, for A. J. Drexel, of Philadelphia. The yacht is a Watson design, and is a large full-powered sea-going vessel of these dimensions: Length over all, 323 ft.; load water line, 272 ft.; beam, extreme, 36 ft. 7 in.; load draft, 16 ft. 8 in. She will have the usual clipper bow, overhung stern, two pole masts with a fore and aft sail spread and one funnel. She is flush decked, the side plating being carried up at the ends, with rail carried on stanchions along the sides of the main deck.

Steel is, of course, the material used for the construction of the hull and also of the decks, the latter being covered with teak. A double bottom is carried the entire length, and there are ten watertight compartments in all. There is a large amount of promenade space on the main deck, as the deck house is not continuous. Just aft of the foremast a small house contains the smoking room and spacious vestibule, with staircase communicating with the chart room and pilot house above and living rooms below. Abaft the funnel there is a spacious skylight or dome over the main dining room, and aft of this come the engine casing, and deck house, containing vestibule and boudoir, all of steel, paneled with teak wood.

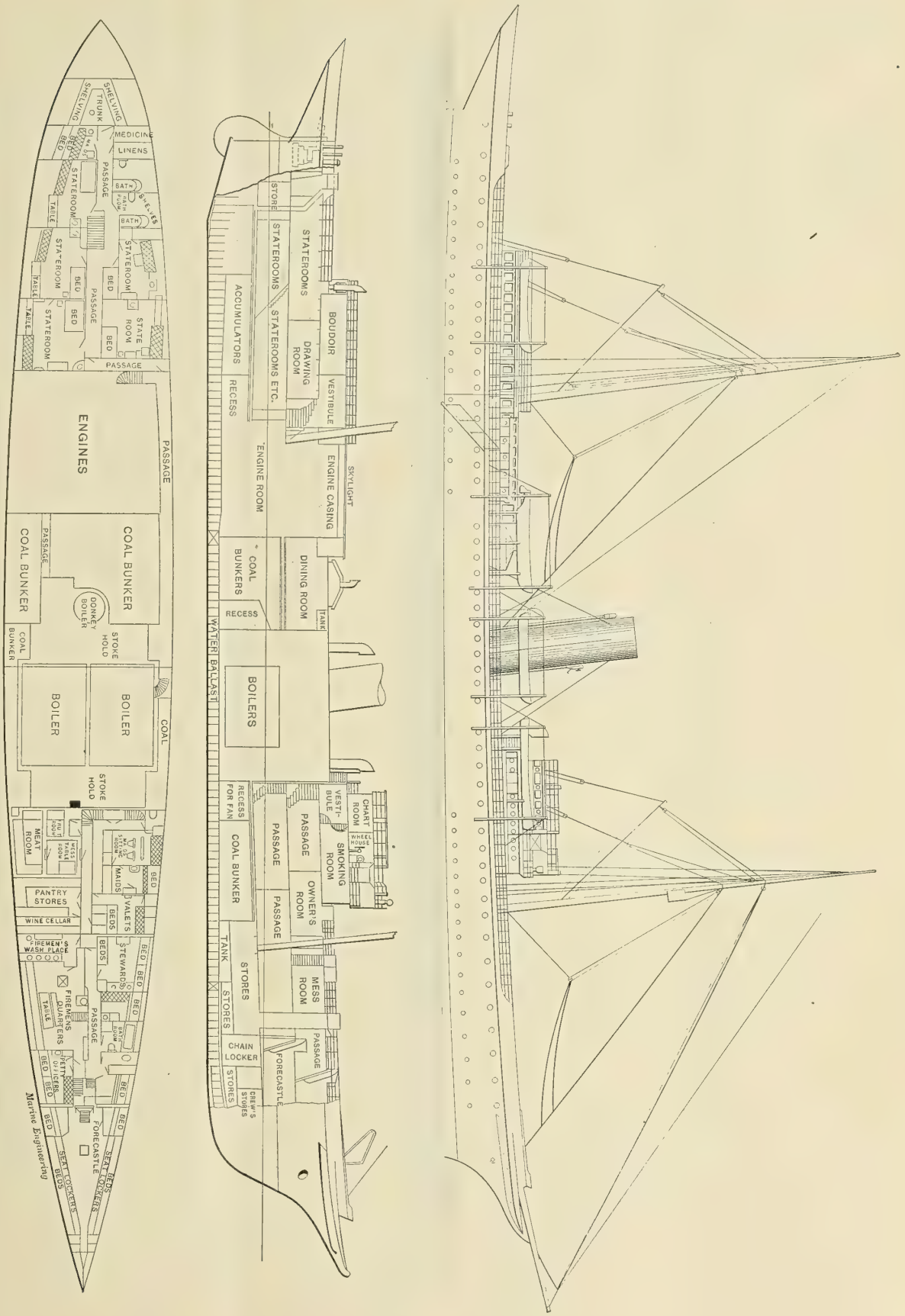
The *Margarita* will have twin screws, driven by triple expansion engines of about 5,000 I.H.P., designed to give a trial speed of 17 knots. Boilers will be of the cylindrical, multitubular type. The coal capacity figures out 550 tons, and there is large water capacity in the double bottom and tanks. A modern equipment of auxiliaries will be carried, including a refrigerating plant with a rated capacity of 1,200 lbs. of ice a day, electric lighting plant of 800 lights capacity, and an extensive system of mechanical ventilation.

As customary in vessels of this class, the scheme of decorating and finishing is very elaborate. The location of the various compartments is shown on the accompanying plans. The drawing room, which will extend the entire width of the ship, will be finished in Louis XV. style, the dining room in Chippendale, and the social hall or library in Empire style. In this room the wood work will be carved Spanish mahogany, with decorated stained glass dome. The smoking room in the forward main deck house will be treated in old English style, with oak paneling, and the boudoir in the after house will be finished in white wood. A rail will be carried around the top of the after house, and this space will be used as an observation platform by the guests. A feature of the equipment will be an armory supplied with rifle caliber automatic guns and small arms.

Eight boats will be supplied, including a steam and a naphtha launch. A crew of sixty-eight men all told will be carried.

It has been the intention to build a roomy, habitable boat in which long voyages can be undertaken in comfort.

A new coaching launch for Harvard to replace the *Frank Thompson* burned recently is to be built by Lawley & Son, of South Boston. The dimensions of the new boat will be: Length, 51 ft.; beam, 7 ft. 10 in., and draft, 3 ft.



SAIL AND ACCOMMODATION PLANS OF THE WATSON DESIGNED S. Y. MARGARITA BUILDING AT GREENOCK, SCOTLAND, FOR A. J. DREXEL, OF PHILADELPHIA.

REVIEW OF PAST PROGRESS IN STEAM NAVIGATION AND FORECAST OF FUTURE DEVELOPMENT.*—III.

BY SIR WILLIAM WHITE, CONSTRUCTOR-IN-CHIEF, R. N.

The earlier theories of resistance assumed that the resistance experienced by ships varied as the square of the speed. We now know that the frictional resistance of clean-painted surfaces of considerable length vary as the 1.83 power of the speed. This seems a small difference, but it is sensible in its effects, causing a reduction of 32 per cent at 10 knots, nearly 40 per cent at 20 knots, and 42 per cent at 25 knots. On the other hand, it is now known that the laws of variation of the residual or wave-making resistance may depart very widely from the law of the square of the speed, and it may be interesting to trace for the typical destroyer how the resistance actually varies.

Take first the total resistance. Up to 11 knots it varies nearly as the square of the speed; at 16 knots it has reached the cube; from 18 to 20 knots it varies as the 3.3 power. Then the index begins to diminish; at 22 knots it is 2.7; at 25 knots it has fallen to the square; and from thence to 30 knots it varies practically as does the frictional resistance. The residual resistance varies as the square of the speed up to 11 knots; as the cube, at 12 1-2 to 13 knots; as the fourth power, about 14 1-2 knots; and at a higher rate than the fifth power at 18 knots. Then the index begins to fall, reaching the square at 24 knots, and falling still lower at higher speeds. It will be seen, therefore, that when this small vessel has been driven up to 24 or 25 knots by a large relative expenditure of power, further increments of speed are obtained with less proportionate additions to the power.

Passing from the destroyer to the cruiser of similar form but of 14,100 tons, and once more applying the scale of comparison, it will be seen that to 25 knots in the destroyer corresponds a speed of 47 1-2 knots in the large vessel. In other words, the cruiser would not reach the condition where further increments of speed are obtained with comparatively moderate additions of power until she exceeded 47 knots, which is an impossible speed for such a vessel under existing conditions. The high speeds that could be reached by the cruiser with propelling apparatus of the lightest type yet fitted in large sea-going ships would correspond to speeds in the destroyer, for which the resistance is varying as the highest power of the speed. These are suggestive facts.

Frictional resistance, as is well known, is a most important matter in all classes of ships and at all speeds. Even in the typical destroyer this is so. At 12 knots the friction, with clean-painted bottom, represents 80 per cent of the total resistance; at 16 knots, 70 per cent; at 20 knots a little less than 50 per cent; and at 30 knots 45 per cent. If the coefficient of friction were doubled, and the maximum power developed with equal efficiency, a loss of speed of fully 4 knots would result. In the cruiser of similar form the friction represents 90 per cent at 12 knots, 85 per cent at 16 knots, nearly 80 per cent at 20 knots, and over 70 per cent at 23 knots. If the coefficient of friction were doubled at 23 knots, and the corresponding power developed with equal efficiency, the loss of speed would approximate to 4 knots. These illustrations only confirm general experience that clean bottoms are essential to economical propulsion and the maintenance of speed, and that frequent docking is necessary in vessels with bare iron or steel skins which foul in a comparatively short time.

POSSIBILITIES OF FURTHER INCREASE IN SPEED.

From the facts previously mentioned it is obvious that the increase in speed which has been effected is the result of many improvements, and has been accompanied by large additions to size, engine power, and cost. These facts do not discourage the inventor, who finds a favorite field of operation in schemes for attaining speeds of 50 to 60 knots at sea in vessels of moderate size. Sometimes the key to this remarkable advance is found in devices for reducing surface friction by the use of wonderful lubricants to be applied to the wetted surface of ships, or by interposing a layer of air between the skins of ships and the surrounding water, or other departures from ordinary practice. If these gentlemen would "condescend to figures" their estimates or guesses would be less sanguine. In many cases the proposals made would fail to produce any sensible reduction in resistance; in others it would increase resistance. Other proposals rest upon the idea that resistance may be largely reduced by adopting novel forms, departing widely from ordinary ship shapes.

Very often small-scale experiments, made in an unscientific and inaccurate manner, are adduced as proofs of the advantages claimed. In other instances mere assertion is thought sufficient. Ordinarily no regard is had to other considerations, such as internal capacity, structural weight and strength, stability, and seaworthiness. Most of these proposals do not merit serious consideration. Any which seem worth investigation can be dealt with simply and effectively by the method of model experiments. A striking example of this method will be found in the usual form of a parliamentary paper—No. 313 of 1873—containing a report made by William Froude to the Admiralty. Those interested in the subject will find therein much matter of special interest in connection with the conditions attending abnormally high speeds. It must suffice now to say that ship-shaped forms are not likely to be superseded at present.

The most prolific inventions are those connected with supposed improvements in propellers. One constantly meets with schemes guaranteed by the proposers to give largely increased efficiency and corresponding additions to speed. Variations in the numbers and forms of screws or paddles, the use of jets of water or air expelled by special apparatus through suitable openings, the employment of explosives, imitations of the fins of fishes, and numberless other departures from established practice, are constantly being proposed. As a rule the "inventors" have no intimate knowledge of the subject they treat, which is confessedly one of great difficulty. When experiments are adduced in support of proposals they are almost always found to be inconclusive and inaccurate. More or less mathematical dem-

*From a paper read before the British Association, Mechanical Science Section.

onstrations find favor with other inventors, but they are not more satisfactory than the experiments. An air of great precision commonly pervades the statements made as to possible increase in efficiency or speed. I have known cases where probable speeds with novel propellers have been estimated—or guessed—to the third place of decimals.

In one such instance a trial was made with the new propeller, with the result that, instead of a gain in efficiency, there was a serious loss of speed. Very few of the proposals made have merit enough to be subjected to trial. None of them can possibly give the benefits claimed. It need hardly be added that, in speaking thus of so-called "inventors," there is no suggestion that improvement has reached its limit, or that further discovery is not to be made. On the contrary, in regard to the forms of ships and propellers, continuous investigation is proceeding, and successive advances are being made. From the nature of the case, however, the difficulties to be surmounted increase as speeds rise; and a thorough mastery of the past history and present condition of the problems of steamship design and propulsion is required as a preparation for fruitful work in the nature of further advance.

It would be idle to attempt any predictions as to the characteristic features of ocean navigation sixty years hence. Radical changes may well be made within that period. Confining attention to the immediate future, it seems probable that the lines of advance which I have endeavored to indicate will remain in use. Further reductions may be anticipated in the weight of propelling apparatus and fuel in proportion to the power developed; further savings in the weight of the hulls, arising from the use of stronger materials and improved structural arrangements, improvements in form, and enlargement in dimensions. If greater drafts of water can be made possible, so much the better for carrying power and speed. For merchant vessels commercial considerations must govern the final decision; for warships the needs of naval warfare will prevail. It is certain that scientific methods of procedure and the use of model experiments on ships and propellers will become of increased importance. Already avenues for further progress are being opened. For example, the use of water-tube boilers in recent cruisers and battleships of the royal navy has resulted in saving one-third of the weight necessary with cylindrical boilers of the ordinary type to obtain the same power, with natural draft in the stokeholds.

Differences of opinion prevail as to the policy of adopting particular types of water-tube boilers; but the weight of opinion is distinctly in favor of some type of water-tube boiler in association with the high steam pressures now in use. Greater safety, quicker steam raising, and other advantages as well as economy of weight, can thus be secured. Some types of water-tube boilers would give greater saving in weight than the particular type used in the foregoing comparison with cylindrical boilers. Differences of opinion prevail also as to the upper limit of steam pressure which can with advantage be used, taking into account all the conditions in both engines and boilers. From the nature of the case, increases in pressure beyond the 160 lb. to 180 lb. per square inch commonly reached with cylindrical boilers cannot have anything like the same effect upon economy of fuel as the corresponding increases have had, starting from a lower pressure. Some authorities do not favor any excess above 250 lb. per square inch on the boilers, others would go as high as 300 lb., and some still higher.

Passing to the engine-rooms, the use of higher steam pressures and greater rates of revolution may and probably will produce reductions in weight compared with power. The use of stronger materials, improved designs, better balance of the moving parts, and close attention to details have tended in the same direction without sacrifice of strength. Necessarily there must be a sufficient margin to secure both strength and endurance in the motive power of steamships. Existing arrangements are the outgrowth of large experience, and new departures must be carefully scrutinized. The use of rotary engines, of which Mr. Parsons' turbomotor is the leading example at present, gives the prospect of still further economies of weight. Mr. Parsons is disposed to think that he could about halve the weights now required for the engines, shafting and propellers of an Atlantic liner, while securing proper strength and durability. If this could be done in association with the use of water-tube boilers, it would effect a revolution in the design of this class of vessels, permitting higher speeds to be reached without exceeding the dimensions of existing ships.

It does not appear probable that, with coal as the fuel, water-tube boilers will surpass in economy the cylindrical boilers now in use; and skilled stoking seems essential if water-tube boilers are to be equal to the other type in rate of coal consumption. The general principle holds good that as more perfect mechanical appliances are introduced, so more skilled and disciplined management is required in order that the full benefits may be obtained. In all steamship performance the "human factor" is of great importance, but its importance increases as the appliances become more complex. In engine-rooms the fact has been recognized and the want met. There is no reason why it should not be similarly dealt with in the boiler-rooms.

Liquid fuel is already substituted for coal in many steamships. When sufficient quantities can be obtained it has many obvious advantages over coal, reducing greatly manual labor in embarking supplies, conveying it to the boilers, and using it as fuel. Possibly its advocates have claimed for it greater economical advantages over coal than can be supported by the results of extended experiment. Even if the saving in weight for equal evaporation is put as low as 30 per cent of the corresponding weight of coal, it would amount to 1,000 tons on a first-class Atlantic liner. This saving might be utilized in greater power and higher speed or in increased load. There would be a substantial saving on the stokehold staff. At present it does not appear that adequate supplies of liquid fuel are available. Competent authorities here and abroad are giving attention to this question, and to the development of supplies. If the want can be met at prices justifying the use of liquid fuel, there will undoubtedly be a movement in that direction.

Stronger materials for the construction of hulls are already available. They are, however, as yet but little used, except for special classes of vessels. Mild steel has taken the place of iron, and effected considerable

savings of weight. Alloys of steel with nickel and other metals are now made, which give strength and rigidity much superior to mild steel, in association with ample ductility. For destroyers and torpedo boats this stronger material is now largely used. It has also been adopted for certain important parts of the structures of recent ships in the royal navy. Of course, the stronger material is more costly, but its use enables sensible economies of weight to be made. It has been estimated, for example, that in an Atlantic liner of 20 knots average speed about 1,000 tons could be saved by using nickel steel instead of mild steel. This saving would suffice to raise the average speed more than a knot, without varying the dimensions of the ship. Alloys of aluminium have also been used for the hulls or portions of the hulls of yachts, torpedo boats, and small vessels. Considerable savings in weight have thus been effected. On the other hand, these alloys have been seriously corroded when exposed to the action of the sea water, and on that account are not likely to be extensively used. Other alloys will probably be found which will be free from this defect, and yet unite lightness with strength to a remarkable degree. Other examples might be given of the fact that the metallurgist has by no means exhausted his resources, and that the shipbuilder may look to him for continued help in the struggle to reduce the weights of floating structures.

It is unnecessary to amplify what has already been said as to possible increase in the efficiency and types of propellers. With limited draft, as speeds increase and greater powers have to be utilized, multiple propellers will probably come into use. Mr. Parsons has shown how such problems may be dealt with; and other investigators have done valuable work in the same direction. In view of what has happened, and is still happening, it is practically certain that the dimensions of steamships have not yet attained a maximum. Thanks to mechanical appliances, the largest ships built, or to be built, can be readily steered and worked. In this particular difficulties have diminished in recent years notwithstanding the growth in dimensions. Increase in length and weight favors the better maintenance of speed at sea. The tendency, therefore, will be to even greater regularity of service than at present. Quicker passages will to some extent diminish risks, and the chance of breakdown will be lessened if multiple propellers are used. Even now, with twin screws, the risk of total breakdown is extremely small.

Whatever may be the size and power of steamships there must come times at sea when they must slow down and wait for better weather. But the larger and longer the vessel the fewer will be the occasions when this precaution need be exercised. It must never be forgotten that as ships grow in size, speed, and cost, so the responsibilities of those in charge increase. The captain of a modern steamship needs remarkable qualities to perform his multifarious duties efficiently. The chief engineer must have great powers of organization as well as good technical knowledge, to control and utilize most advantageously the men and machinery in his charge. Apart from the ceaseless care, watchfulness and skill of officers and men, the finest ships and most perfect machinery are of little avail. The "human factor" is often forgotten, but is all-important. Let us hope that in the future as in the past, as responsibilities increase so will the men be found to bear them.

Schichau Torpedo Boats.

Among the foreign builders of vessels of the torpedo classes, F. Schichau of Elbing, West Prussia, has a high standing and reputation. His first boat was built for the Russian Government in 1877, and was a small affair with a speed of 16 knots. Since that time this German builder has turned out a very large number of vessels, not only for the Navy of his own country, but for the Governments of Russia, Italy, Austria, Norway, Sweden, Turkey, China, Japan and Brazil. We print herewith a typical group of vessels by this builder, ranging from a small torpedo boat for the Russian Government to the large full-powered destroyers which he recently turned out for China. The originals of these views are by one of the most famous German marine painters, and are made from actual sketches, showing the behavior of these small craft in various seas. In our issue of March, 1899, we published particulars of one of the new Schichau destroyers built for China, for which a trial speed (light) in excess of 35 knots was claimed. This speed, too, was secured with the use of reciprocating engines. In our own navy we have one Schichau vessel, the torpedo boat *Somers*. She is a single screw boat of 143 tons displacement, and quadruple expansion engines of 1,700 horse power, and has a maximum speed of 23 knots. Her boiler is of the now abandoned marine locomotive type. This boat was purchased during the Spanish war.

Annual Report.—The annual report of the Secretary of the Treasury shows that the work performed by vessels of the Revenue Cutter Service during the year, aside from participation in naval operations during the Spanish war, included the following: Miles cruised, 239,061; lives saved from drowning, 18; vessels boarded and papers examined, 18,039; vessels seized and reported for violations of law, 142; fines and penalties incurred by vessels reported, 28,970; vessels in distress, 111; value of vessels assisted and their cargoes, $1,735,762; persons on board vessels assisted, 946; persons in distress taken on board and cared for, 62. Two new vessels for the service will soon be contracted for, one for the Great Lakes and the other for the Pacific coast. It is again recommended that several of the old cutters be sold out of the service and that as many new vessels be built to replace them.

U. S. Foreign Commerce.—For the fiscal year ending June 30, 1899, the foreign commerce of the United States reached a total of $1,924,171,000. This includes all exports and imports, other than gold and silver. Of this total, New York got the largest share, the imports amounting to $465,559,650 and exports $459,444,217. Boston comes next, with imports footing up $52,097,960 and exports $128,037,149. Of the other cities only Baltimore and Philadelphia transacted a business in excess of $100,000,000 during the year.

New Revenue Cutter.—Designs for a new revenue cutter for the Great Lakes have been prepared by the engineering staff of the service. The new vessel is to be of these dimensions: Length, 178 ft.; beam, 30 ft.; depth, 15 ft. She will be fitted with triple expansion engines with cylinders 17 in., 27 in. and 43 in. dia. and 24 in. stroke. Steam will be generated in two single ended cylindrical boilers at a working pressure of 160 lb. The new vessel will be built of steel and will cost about $165,000.

SKETCHES OF SCHICHAU BUILT TORPEDO BOATS AND DESTROYERS BUILT FOR RUSSIAN, CHINESE AND BRAZILIAN NAVIES, DRAWN BY HANS BOHRDT FROM STUDIES MADE AT SEA.

COMPARISON BETWEEN PERFORMANCES OF TWO SEA-GOING STEAMSHIPS.*—III.

BY J. D. M'ARTHUR, MEMBER.

With regard to the distribution of power in the cylinders, B was at a great disadvantage compared with A, for while in the latter the division of work was fairly uniform, in B the opposite obtained, the L.P. engine developing power fully 30 per cent, and the L.P. also, in excess of the H.P.

This was partly original sin, considerably augmented, however, by the bad state of the H.P. cylinder barrel and piston. The former tapered 1-8 in. between the top and bottom, the larger diameter being 24 7-16 in., or 7-16 in. greater than the original size, and this after barely four years' running. The barrel was separate from the cylinder, but appeared to have been cast of sole-plate metal, softer if anything, and chipping ridges off was a constant job.

Originally the H.P. piston had a flat junk-ring, and a floating or bull ring, fitted with Ramsbottom springs, 3-4 in. square section; but on her first voyage one of the junk-ring bolts worked back, breaking the junk-ring and bending the rod. The new ring supplied had the bull-ring cast in one piece with it, Ramsbottom springs being still adhered to. During a subsequent voyage, another junk-ring bolt was thrown out, this time, however, incredible as it may seem, without doing any damage. The ship at the time was within a few hours of port, on a lee shore, with a strong breeze blowing. After arrival the casing cover was lifted, and the bolt found in two pieces, having been cut by the piston valve as clean as if done in a shearing machine. The clearance spaces in all the cylinders were large, and those above the pistons were increased by the amount the engines were down. This fact probably saved the cylinder cover from being knocked off or the piston rod from again being bent, for the bolt (1 1-4 in. diameter) must have slacked well back out of the nut first, and then jumped clear of the hole on the down stroke, lain flat on the piston, and been carried by the exhausting steam through the port to the piston valve, which sheared it through on its up-stroke when closing the port to exhaust, a slight indentation on the edges of the valve and port being the only visible damage.

Even when the springs were new, however, and the piston in a fairly tight condition, the power developed in the I.P. engine preponderated, although the L.P. expansion was shut well in, showing clearly that the valve and the pulleys required alteration. Expansion blocks were without grades or marks of any description, so the only guide to the position of cut-off was the indicator card, and time in port abroad was too fully occupied in carrying on the necessary work to have any to devote to valve-setting.

As has been already mentioned, both the steering and fan engines received steam at full boiler pressure. The valves of steering engines, in order to permit of reversal with a single fixed eccentric, possess neither lap nor lead, and so these engines are extremely wasteful of steam, both with regard to the quantity required to drive them and through leakage past the valves. Working under such a high pressure as 160 lbs., and exhausting to the condenser at practically that same pressure, the loss of heat is all the greater, leaving out of account the increased difficulty of keeping the glands tight, and the loss thereat. The case of the fan engine is, perhaps, not so bad, but still a more economical result might be attained by the use of steam reduced to 80 lb., or thereabouts. If instead of exhausting into the condenser, these engines, or others similarly wrought, were arranged so that their exhausts could be turned into the L.P. casing when at sea, the effect would probably be beneficial—first, by slightly increasing the pressure; and, secondly, by surrendering their excess of heat, and so diminishing condensation in the casing, thus increasing the power of the L.P. engine in two ways, without increasing the back pressure on the pistons to any great extent by reason of the bends and length of piping.

The condenser itself was a conspicuous source of loss, but the fault in this case lay not so much with the design as the management at sea; although, so far as could be learned, the vacuum was from the first more or less bad. An attempt to reduce the wearing and scoring of the H.P. cylinder by a lavish application of oil soon made its effects felt both in the condenser and boilers. It would appear that engine-oil had been used to make the valve-oil spin out, its probable effect on the boilers never being taken into account till corrosion obtained a good hold, particularly of the lower parts of combustion chambers, lower water-space stays and steam-space stays. One or two of the combustion chamber back plates also showed signs of buckling, and the dirt which caused this very probably owed some part of its non-conducting quality to the presence of grease. After the use of oil was discontinued the corrosion in a great measure ceased, but having once got a hold in places where the plates and stays cannot be scraped thoroughly clean, its progress is still manifest in spite of a liberal distribution of zinc plates over the worst affected spots, and the daily injection of soda.

The ratio of heating surface in the boilers to cooling surface in the condenser was as two to one, and at the power usually developed there were 2 sq. ft of cooling surface per I.H.P. The air-pump being also of ample size, and in fairly good order, there was no apparent reason why the vacuum should not have been originally good, but to such an extent had grease accumulated on the outside of the tubes, and scale on the water side, that in water of the temperature of 78 deg. to 80 deg., only 17 in. of vacuum was obtainable, the temperature of the hot well being 185 deg., and the discharge water 110 deg. The high temperature of the hot well necessitated the vapor from the evaporator being discharged into the condensor, which, besides further impairing the vacuum, greatly enhanced the cost of the fresh water. This result was achieved in less than four years, during the regime of three chief engineers, without apparently exciting much comment.

From what has been already mentioned of the prevalence of dust in the engine-room, it will hardly be necessary to say that the wear and tear of bearings, etc., in B was much greater than in A, the common

* Read before the Institute of Marine Engineers, London, England.

rate of wear of the guide-shoes, for instance, being about 1-8 in. in six months, more, rather than less; this, of course, did not help the packing in any way, and on a long run meant stopping and lining up.

Several other features of the general arrangement afforded scope for improvement, but as they have no bearing on the economical aspect of the question, they may be left out of account, so that the only points remaining which call for comment are the propellers and design of the hulls. Both ships were provided with propellers of the ordinary four-bladed type, A's being 18 ft. 6 in. dia. and 18 ft. pitch; B's 16 ft. 6 in. dia. and 17 ft. 6 in. pitch, the pitch being uniform in both cases, and blades of steel. In smooth water, at ordinary speed, the apparent slip of A's propeller was about 6 per cent, and during a voyage, in which no very strong or incessant head-winds were encountered, it did not, as a rule, much exceed 11 to 12 per cent, the ship possessing a fairly easy entrance and good run. On the other hand, in B, model was entirely sacrificed to carrying capacity, the entrance being very bluff, the run and under-water body very full. The actual values of the co-efficients of displacement and circumscribing rectangle are unknown to the author, but, judging from appearance, these must have been pretty close to the highest found in ordinary practice, and were unmistakably greater than those of A. With bottom freshly painted, and just out of dry dock, in smooth water, the slip of B's propeller was not less than 10 or 11 per cent, and it rose very quickly with even a moderate head-wind or swell, showing that to a great extent the bluffness of form brought about a loss of performance not at all compensated for by the slightly additional percentage of carrying power so gained. In conclusion, it may be noted that, while A was a stiff ship, and a heavy roller in a sea-way, B was crank, but an excellent sea boat. Loaded full to the hatches, with a homogeneous cargo of sufficient weight to submerge her to the ordinary draught, the metacentric height must have been very small, practically nil for small angles of heel, although at greater angles it was evidently sufficient, and the range of stability good enough. It was almost an impossibility to keep her on an even keel, however, and it only required a moderate breeze on the beam to list her over 3 deg. or 4 deg., where she would lie until either the wind came off the other side, or sufficient coal had been worked off the low side to bring her up. She had more tumble-home in her sides than is usual nowadays, and this, by reducing the beam at the load water-line, together with the fullness of her under-water form, and consequently greater displacement, would assist in lowering the metacenter, but that point will be left open for the opinion of those better acquainted with the subject. She was fitted with bilge keels, or rolling chocks, and that these materially help to steady a ship can be realized by anyone who has watched the surging and boiling of the water caused by them as the ship rolls in a heavy sea. To these, and the fact of her being tender, the safety of the ship and lives on board of her may be ascribed; for had she been a heavy roller in the weather and under the conditions experienced not long ago, this paper would probably never have been written.

Stated briefly, in order to be readily seen for discussion, the various advantages, or supposed advantages, of A over B may be grouped together as follows: (1) Equal distribution of power between the cylinders. (2) Use of a slide valve in H.P. cylinder, as compared with a block piston-valve, and greater steam-tightness of valve and piston. (3) Increased temperature of feed, and saving by Weir's system of feed-heating. (4) Use of steam in auxiliary engine at press. of 80 lbs., reduced from 160 lbs. (5) Difference in arrangement of dead-plates, and smaller area of funnel per square foot of grate. (6) Improved wear of bearings, guide-faces, etc., with corresponding less friction and loss at glands. This, of course, had the effect, outside of the question of fuel, of a diminished expenditure on up-keep, to such an extent that B's bill at the end of four years for tear and wear was many times greater than A's. (7) Cooler stokehold, enabling steam to be kept steadier, and greater attention paid to correct stoking during at least part of a voyage. (8) Better vacuum. In taking B's consumption at 1.7 lb per I.H.P., vacuum is equivalent to 23 in. with sea water of 55 deg. (9) Smaller co-efficient of fineness and smaller percentage slip of propeller. This, while not affecting the lbs. per I.H.P., has a direct bearing on the consumption per ton per mile, which is the more important aspect from the ship-owner's point of view.

The author regrets that, while in the main the figures given in this paper are correct, so far as known, he cannot vouch for the accuracy of them all, as through notes becoming mislaid they had to be supplied from memory; also, that no indicator cards can be produced, as they were destroyed by water. Such items as lb. per I.H.P., and consumption per ton per mile, are closely approximate to the actual conditions of working, and the differences between them can be readily seen.

Lake Side Wheel Steamer Tashmoo.

A fine new fast passenger vessel for service on the Great Lakes between Detroit and Port Huron was launched from the yard of the Detroit Shipbuilding Company December 30 last. She is named the *Tashmoo*, and will run under the flag of the White Star Line of the lakes. A general idea of the appearance of the new vessel when at sea can be had from the accompanying drawing. She is not unlike vessels on the Sound service running out of New York.

The *Tashmoo* is the largest and most costly vessel ever built for the service. Her general dimensions are: Length, overall, 315 ft.; on load water line, 301 ft.; beam of hull, 37 ft. 6 in.; overall, 70 ft.; depth, 13 ft. 6 in. Accommodation for 2,500 passengers is arranged for. In the group of photographs those of the hull give a suggestion of her fine lines, the vessel having been designed for high speed. An innovation is the balanced rudder plainly seen in the view from astern. The hull is of mild steel, and is divided into six compartments by five watertight bulkheads. As the drawing shows, the vessel is a side-wheeler, with feathering paddles, 22 ft. 4 in. dia., 12 ft. face, each having 9 floats 4 ft. wide. The wheels will be driven by a set of inclined triple expansion direct connected engines, with cylinders 33 in., 51 in., and 82 in. dia. and 6 ft. stroke. Two views of these engines while being assembled in the erecting shop are here given, and show their size and the workman-like character of design. The H. P.

cylinder is placed between the I. P. and L. P. cylinders, and is fitted with a piston valve. Both the other cylinders have double-ported slide valves, and will be handled by direct steam reversing engine. An injection condenser is fitted, the vessel being built for fresh-water service, and the air pump will be worked by levers from the H. P. crosshead. By an arrangement of suitable valves and tanks the discharge water can be used for trimming the vessel when required.

Steam will be furnished by two double ended and three single ended boilers of the cylindrical fire-tube type, each 11 ft. 1 in. dia. There will be a total of fourteen furnaces, each 44 in. dia., and the uptakes will be connected to two stacks 6 ft. 9 in. dia., and 60 ft. high above the grates.

Much care has been taken with the finishing of the interior and scheme of decoration. On the main deck the saloon and lobby will be finished in quartered oak and the café in mahogany. Mahogany will also be used in finishing the saloon on the promenade deck. At the sides five parlors are arranged, with bay windows, each room being finished and furnished in a different style. A smoking room is located forward on the upper deck.

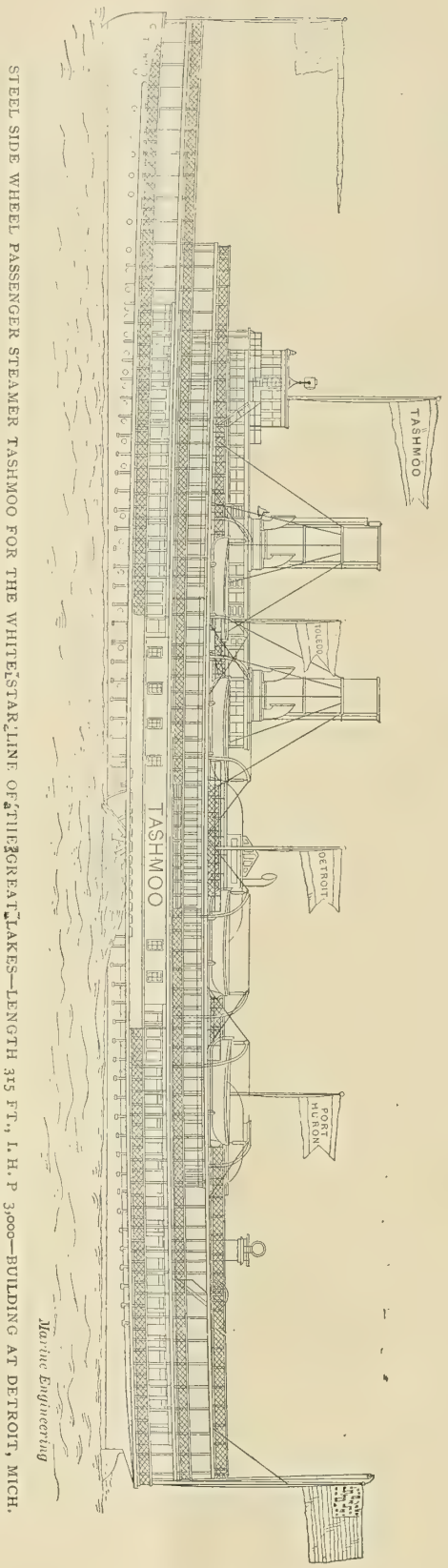
For handling the vessel a complete instalment of machinery will be fitted, including steam capstans, steam steerer and the usual equipment of boats and rafts required by law will be carried.

This fine vessel was designed by Frank E. Kirby, and she is expected to be ready for service in June.

Transport Mishaps.—The transfer of so large an army from the British Isles to South Africa during the present campaign has not been carried out without some disaster, but though there has been a large loss of property and war material there has, curiously enough, been no attendant loss of life. The mishaps commenced with the loss of about 250 horses, through heavy seas on the S.S. *Rapidan* bound out from Liverpool, before she had cleared the Irish coast. The *Ismore*, a new vessel of 5,000 gross tons, was wrecked at the Cape of Good Hope, with detachments of various corps, 250 horses, and valuable stores on board. A loss nearer home was that of the collier *Maltby*, which stranded when leaving the mouth of the river Tyne on the East coast of England and became a total loss. Another large steamer, the *Denton Grange* touched bottom at Las Palmas, Canary Islands, and is now the subject of salvage operations.

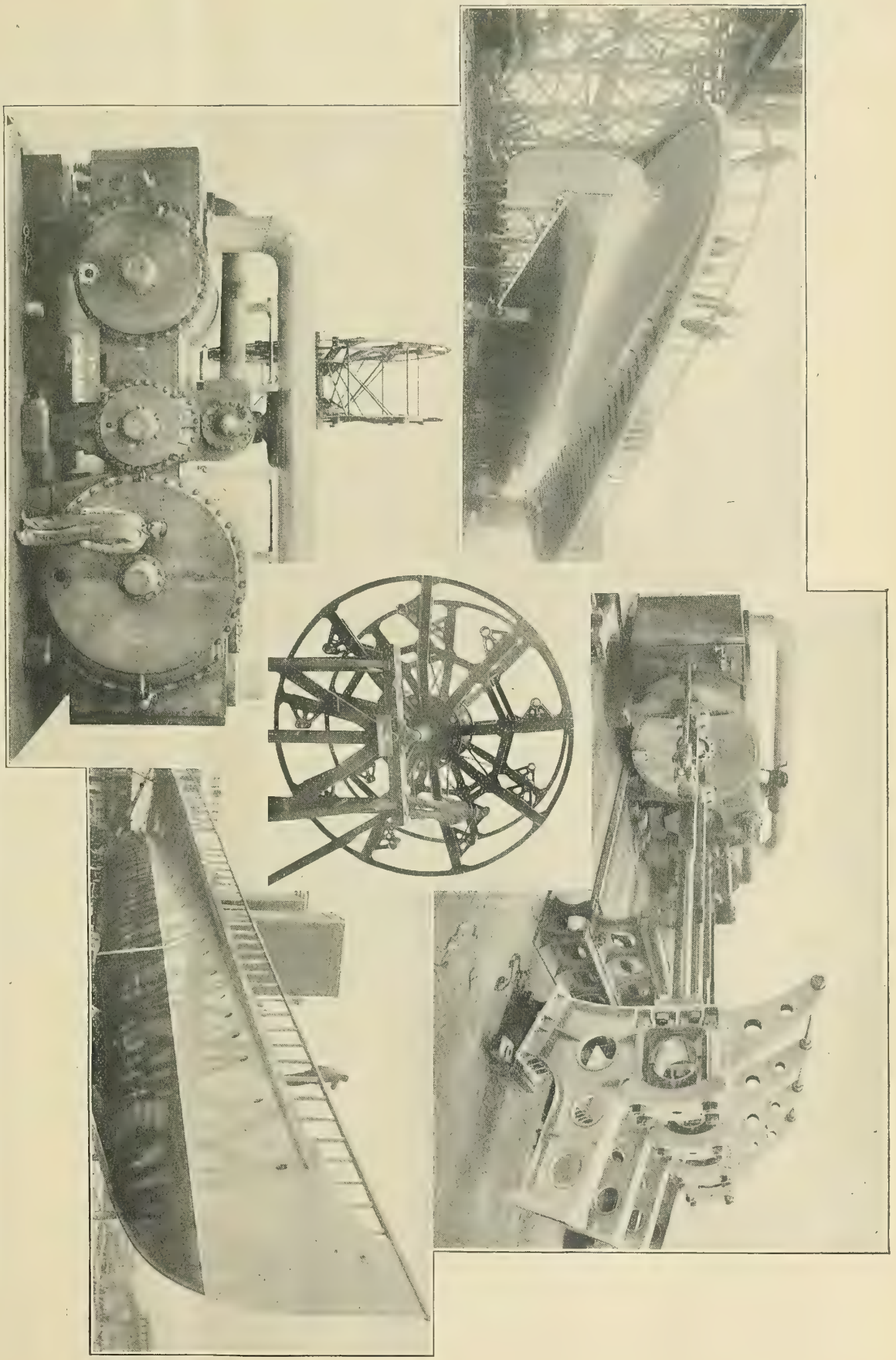
Chicago Drainage Canal.—Water was recently let into the Chicago drainage canal which now gives a waterway for deep draft vessels from the Chicago river to Lockport, Ill. Co-operation of various commercial bodies is now being sought to get a Congressional appropriation for the purpose of extending the ship canal from Lockport to the Illinois river, and thence to the Mississippi river, so that vessels drawing not more than 16 ft. could pass from the Great Lakes to the Gulf of Mexico. It is estimated that this extension would cost about $25,000,000.

Transfer of the ownership of the S.S. *Brasilia*, 10,000 gross tons, from the Hamburg-American line to the Dominion line flag is reported.



STEEL SIDE WHEEL PASSENGER STEAMER TASHMOO FOR THE WHITE STAR LINE OF THE GREAT LAKES—LENGTH 315 FT., I. H. P. 3,000—BUILDING AT DETROIT, MICH.

Marine Engineering



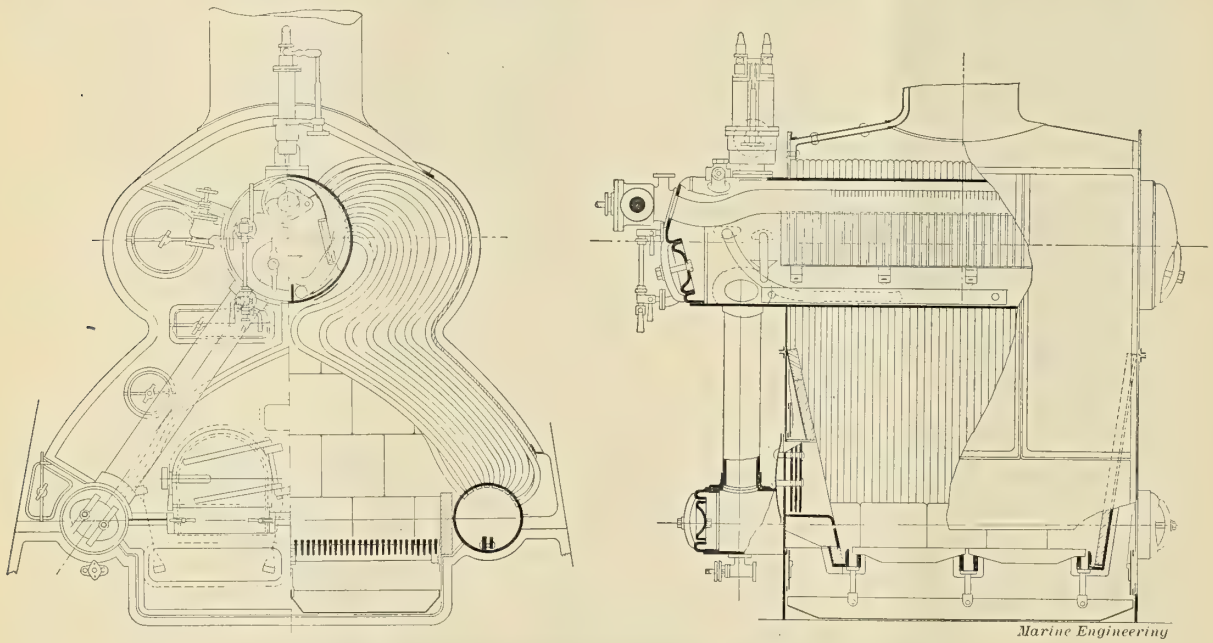
HULL OF THE LAKE SIDE WHEEL STEAMER TASHMOO ON THE BLOCKS; ALSO ENGINES IN COURSE OF ERECTION AND ONE FEATHERING WHEEL, IN DETROIT SHIPYARD.

COMMERCIAL TYPES OF WATER TUBE BOILERS BUILT IN AMERICA.—II.

DESCRIPTIONS OF THORNYCROFT, TAYLOR AND ROBERTS BOILERS WITH SECTIONAL DRAWINGS.

Thornycroft Water-tube Boiler.

This boiler is of the small bent tube type, without screwed joints or connections in contact with the fire. It has generally been built with the tubes discharging above the water level into the top drum. The original or "Speedy" type of this boiler is shown in the drawings published herewith, and it is probably most generally known. In this there is a central steam and water drum situated over the furnace, and connected by bent tubes to two lower drums at the bottom, one on each side, at about the level of the grate. Each tube is in one continuous length and is expanded in place, the drums being of sufficient thickness where the tubes enter to ensure absolute tightness. The tubes nearer the furnace are brought together to form practically a solid wall, except at the lower ends, where they are staggered to permit of the upward flow of gases, while the outer rows are arranged to form a wall, except at the extreme upper ends, where the gases pass through to the smoke pipe. By this placing of the tubes in a series of walls the gases are made to pass among all the small tubes and give up their heat on the way from the grate to the stack. At the upper ends it will be noticed the tubes are curved so that all enter the drum above the water level; therefore, when the boiler is filled ready for steaming and the fire is lit, the heat passing over all the small tubes causes a very rapid upward circulation of water, portion of which is converted into steam. The return of the water to the lower side drums is effected by two water tubes of large diameter fitted at one end of the boiler outside the casing. The mixture of water and steam, carried up through the small tubes, is discharged against a baffle plate in the upper drum, while the steam is carried off by the dry pipe situated underneath the crown of the baffle plate. For purposes of inspection and repair easy access is had to the interior of the drums through manholes in the ends. A modification of this form of boiler styled the "Daring" type is also regularly built where a much larger unit is desired. This consists, in general, of one large upper steam and water drum, a lower and smaller central drum, and two still smaller outside drums. There are two grates, situated between the lower central and outside drums. All the drums are connected by vertical down take pipes of large diameter, and the generating tubes are of small diameter, arranged substantially the same as those in the "Speedy" type. The Thornycroft boiler is named after the torpedo craft builders, John I. Thornycroft & Co., of London, by whom it was designed and installed in a very large number of high speed vessels. In this country the boiler is controlled by Thorpe, Platt & Co., 97-99 Cedar St., New York. In Government work here extensive use has been made of the Thornycroft boiler, hitherto in smaller vessels; but at the present time there are several installations of this type planned for large war vessels, including the battleships *Ohio* and *Missouri*. The total built or building for the U. S. Government on both the Atlantic and Pacific coasts is about 200,000 horse power.

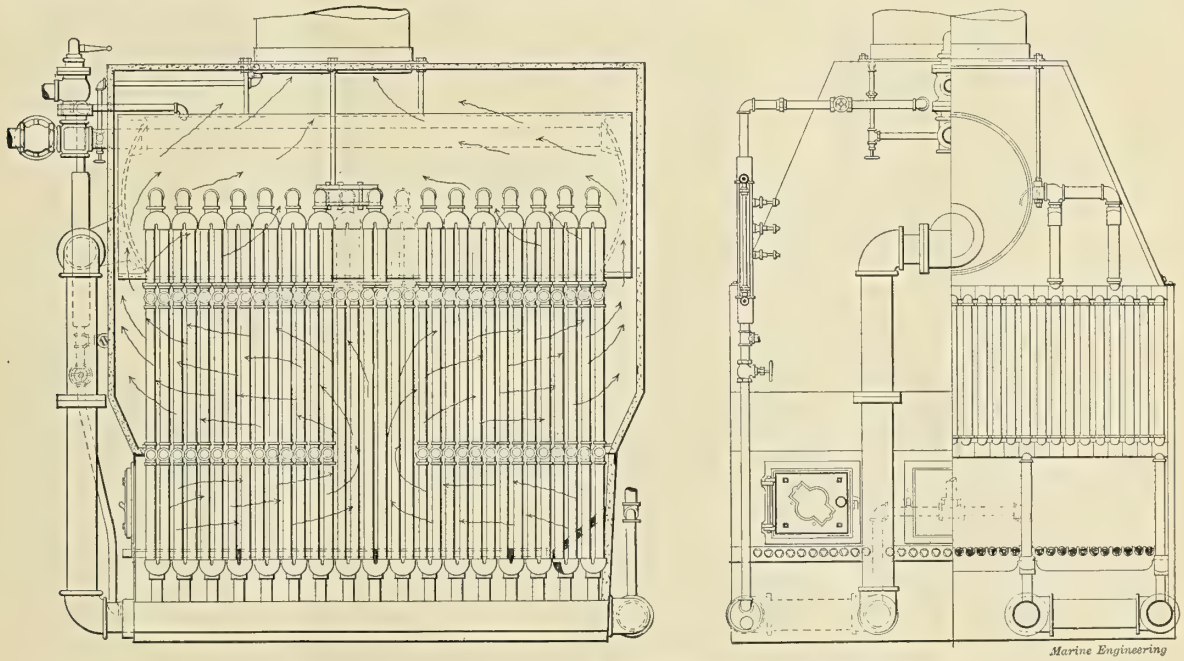


SECTIONAL ELEVATIONS OF THE THORNYCROFT WATER TUBE BOILER.

Taylor Water-Tube Boiler.

Though of the small tube type this boiler differs very much in construction from others which have screwed connections throughout. All the generating tubes are vertical except for the short lengths at the upper ends, where some of the tubes are carried horizontally in a row on each side into the drum at about the water level.

It is also termed a "sectional" boiler, for the reason that it is built up of sections of tubes rather than of separate tubes, and this is made the claim for ease of repair, which will be referred to later. In general the boiler consists of a large number of short straight vertical water tubes over the fire, connected with headers, which in turn are connected with manifolds at the bottom and a steam and water drum extending lengthwise of the boiler at the top. As shown in the accompanying drawings, there are four large bottom manifolds reaching from front to rear of the boiler at some distance below the grate. From these two or four downflow pipes arise outside the casing (back and front) and connect with the drum below the water line. Connection is also made with the bottom manifolds by vertical pipes spaced widely apart, which at the grate level are screwed into branch connections, from which the pipes are then carried up in pairs and connected with tees and four way fittings with the nests of generating tubes, which occupy the space all above the combustion chamber and below the drum, and form the principal heating surface of the boiler. These rows of tubes, rising from the bottom manifolds, and extending from back to front of the boiler, divide the furnace into three grates for each of which a door is provided in the casing. The tubes composing the generating system are in short lengths and are fastened together by nipples which are screwed into the end connections, the latter being faced and butted up tightly, so as to protect the threads from the action of the fire, and forming top and bottom headers. Between the drum and the casing on each side—one tube for each section—two rows of tubes extend upward from the generating nests and connect by bends with the drum. The connections at the lower ends of the generating tubes are arranged to form the crown sheet in such a way as to compel the gases to travel in the course indicated by the arrows in the drawing, which is somewhat the same in general direction as in the cylindrical double ended marine boiler. At each end of the section manifolds or headers a plug is fitted, which on removal, permits of examination and cleaning of these manifolds and also permits the introduction of wrenches to unscrew the connecting nipples, so that a damaged tube may be readily removed and replaced. In the steam generating tubes the circulation is not all in one direction; in some the flow is upward and in others downward, the pipes above the nests of tubes with outlets into the drum carrying up comparatively little water to the drum. Inside the drum there is fitted a dry pipe and separator connecting on the outside with the boiler stop valve, and it is claimed by the manufacturers that their boiler is notable for furnishing dry steam. This boiler has been installed on several yachts and other vessels on the Great Lakes. It is manufactured by the Detroit Screw Works, Detroit, Mich.

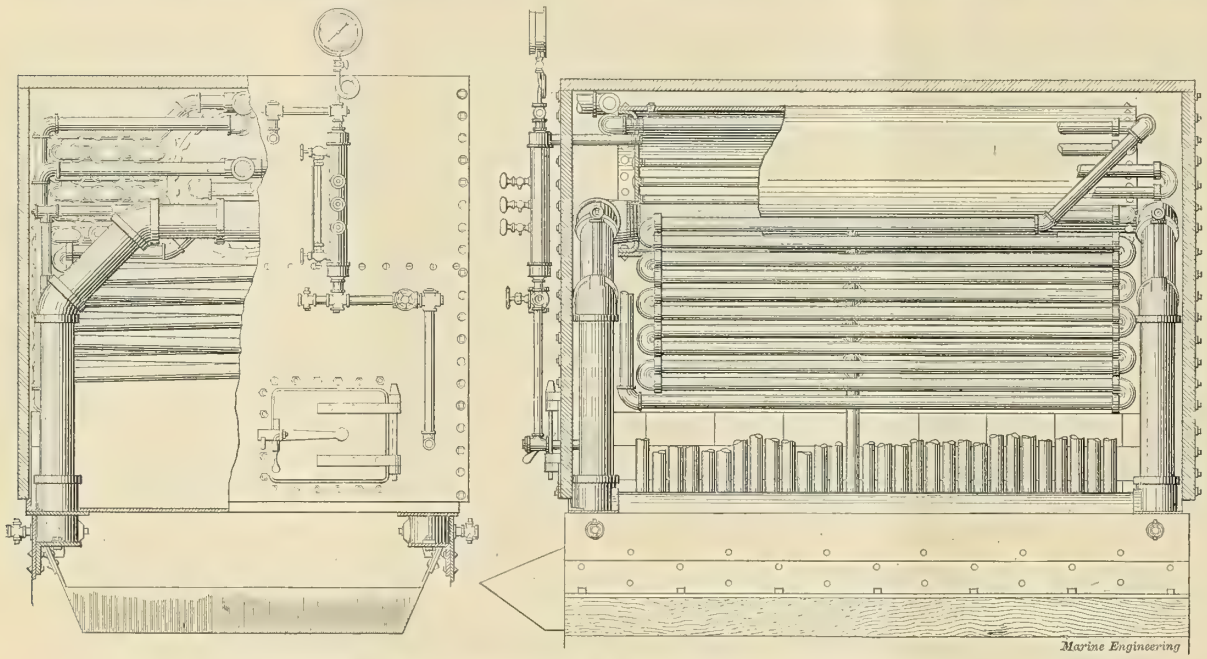


DRAWINGS SHOWING CONSTRUCTION OF THE TAYLOR WATER TUBE BOILER.

Roberts Water Tube Boiler.

When completed, ready for steaming, this boiler is wholly contained within a square box or cube-shaped casing, the only projecting portions being the various connections, such as main steam pipe, feed, blow off, and guages. It is of the submerged small tube variety and in its more usual form consists essentially of three parts—the generating system, the superheater, and the feed heater. The steam generating section of the boiler consists of a steam and water drum at the top of the boiler over the combustion chamber, placed lengthwise from back to front. This is supported on a frame of large-sized downflow pipes, outlining three sides of the box at front and back, the grate forming the remaining side. The lower ends of these pipes are connected by T pieces, with "side pipes" at the level of and parallel with the grate bars. The upper surfaces of these side pipes are drilled and tapped to receive the lower and vertical ends of the "upflow coils," the length

of these lower ends regulating the height of the fire-box. The coils consist of straight lengths of pipe laid horizontally and connected at the ends by malleable steel bends. The upper ends of the coils enter the bottom of the steam drum in a row at each side, a little off the center. By staggering the coils the space between the tubes over the fire is made only one-half that between the vertical ends at the sides of the furnace. At the downflow pipes. At the bottom of each downflow pipe there is a sediment pocket fitted with a blow-off cock. The boiler is stated by the makers to be made of "special" material. All the joints are screwed—there are no expanded joints in the boiler—with standard pipe threads, and the boiler can thus be shipped in parts and erected where needed with ordinary tools. It is made with plain or special grates for burning



DRAWINGS SHOWING CONSTRUCTION OF THE ROBERTS WATER-TUBE BOILER.

the sides of the boiler the superheating coils are laid at right angles to the generating coils. Connection is made between a "spray pipe" in the interior of the drum and the top of the superheater coils at both sides, and from the bottom of each coil a vertical pipe rises and connects with a cross pipe, with T piece at the top—front—of the boiler, to which the steam main is connected. The superheater coils are not carried down as low as the bottom side pipes, the space left being filled with fire bricks, which rest on the bottom frame of the casing, and form a backing to the lower ends of the generating tubes. On top of the generating tubes on each side and above the coiled portions of the superheaters the feed coils are located. The steam drum being of much smaller diameter than the width of the boiler, the feed coils lie snugly between the drum and the sides. A T placed outside the boiler front admits the feed to the upper rows of the feed coils, and from there it flows downward and into the drum above the water line, the coils being connected at their outlets to opposite heads of the drum. In operation the gases pass upward through and over the various coils of pipe—generating, superheating, and feed—to the top of the casing, in the center of which the outlet to the stack is placed. The upflow coils first becoming heated cause the water to ascend from the side pipes to the drum, where the steam and water separate, the steam escaping to the "spray pipe," already referred to, and the water flowing towards the ends of the drum where it reaches either coal or wood. The boiler is manufactured by the Roberts Safety Water Tube Boiler Co., 39-41 Cortlandt St., New York.

S. Y. Victoria and Albert.—A serious mishap befell the new British royal yacht *Victoria and Albert* at Pembroke dockyard recently. Preparations had been made to float her out of dry dock, and when enough water had been let in to float her off the blocks it was found that she would have a considerable list. An effort was made to close the dock again, but the caisson jammed, and when the tide fell the vessel settled on her bilge sustaining some structural damage, though later she was floated again and towed to her moorings. Various criticisms regarding her stability have been published, and it appears to be the fact that some structural changes have been made on this account.

President James J. Hill, of the Great Northern Railroad, who has been credited for some time with the intention of putting a fleet of vessels of immense size in operation on the Pacific coast, to trade to the Orient, is now reported to have given particulars of the scheme. The vessels for the proposed route are to exceed 700 ft. in length and to have a carrying capacity of about 22,000 tons, the intention being to carry vast quantities of freight at economical speed across the Pacific.

Germany is now considering an enormous increase of its navy, the proposed expenditure being not less than $500,000,000.

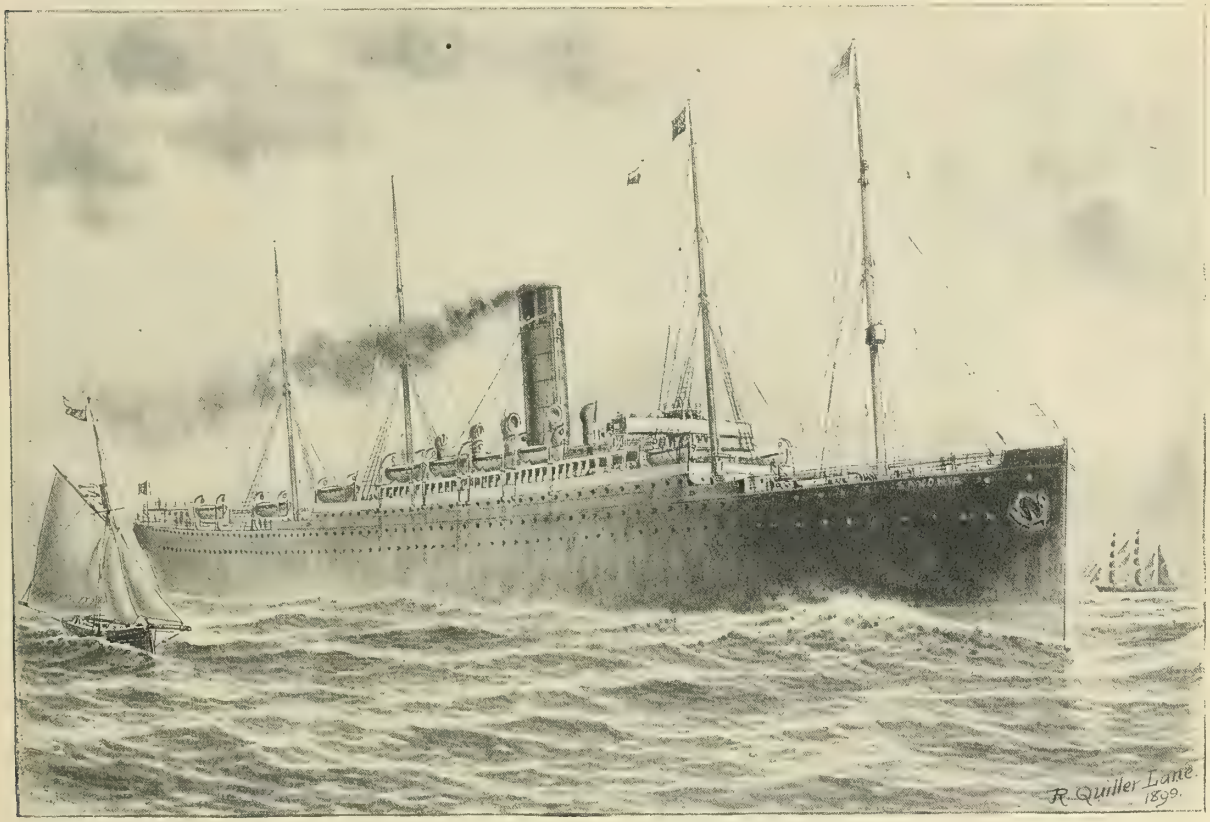
ADDITIONS TO FLEET OF THE CUNARD LINE—S. Ss. SAXONIA AND IVERNIA.

Two important additions to the Boston-Liverpool service of the Cunard line will be made on the completion of the steamships *Saxonia* and *Ivernia*, now building in British yards for the company. In the accompanying engraving the artist has depicted the *Saxonia* steaming at sea, on a transatlantic trip, with the Stars and Stripes flying at the fore. In December the *Saxonia* was launched at the Clydebank yard, now a consolidation of the J. & G. Thomson and John Brown & Company, the armor plate makers of Sheffield, where the well known liners *Paris* and *New York* were turned out. The *Ivernia* was launched about three months ago at the yard of Swan & Hunter, on the east coast of England.

It is undoubtedly the active competition of other lines trading to Boston that induced the Cunard Company to build these ships. For years the Boston passenger boats of that line have been famous for their slowness and general out-of-dateness. In recent days the company put on three large modern cargo and cattle steamers, the *Sylvania*, *Carinthia*, and *Ultonia*. These vessels were, however, no addition to the facilities for carrying cabin passengers on the route.

Both the *Saxonia* and *Ivernia* are liners of the intermediate type, built primarily for carrying freight at a moderate speed, but yet having up-to-date accommodations for a large number of passengers, both cabin and steerage. As a matter of fact the modern additions to the various transatlantic lines are mostly of this type, which is much more profitable to operate than the "record breaker," and for passengers who are not pressed for time on the ocean voyage a more satisfactory ship, everything considered. In dimensions the two vessels will take place near the top of the list of all steamers afloat. The principal dimensions of the *Saxonia* are as follows: Length, between perpendiculars, 580 ft.; over all, 600 ft.; beam, extreme, 64 ft. 3 in.; depth, moulded, from upper deck, 41 ft. 6 in. The gross tonnage will be about 14,000 tons, so that these ships will be the largest sailing to the port of Boston —the largest vessel now trading there being the *New England*, of the Dominion Line, of 12,000 gross tons, which was described in a former issue.

Passenger accommodations will be provided on the *Saxonia* for 164 first-class in the deck house on the bridge deck and below; on the shelter deck aft for about 220 second-class, according to demand; while the steerage quarters for 1,000 will be on the main deck forward. The vessel will have four full decks: Lower, main, upper and shelter, and over the latter a bridge deck, on which the houses containing the library and social hall for cabin passengers will be located. The main dining saloon, which will seat 150 passengers, will be on the shelter deck, lighted by a dome and large side-ports. The decorations and furnishings will be quite modern and a feature will be a more luxurious arrangement of steerage quarters than is usual. Passengers of this class will have bath-room facilities and an extensive promenade, with smoking rooms and ladies' room; with less gilt, perhaps, but otherwise as comfortable as those enjoyed by their fellow passengers in the saloon.



ORIGINAL SKETCH OF NEW CUNARDER SAXONIA, 14,000 GROSS TONS FOR BOSTON TRADE.

Mild steel is used in the construction of the hull, which will conform to the rules of the highest class of Lloyd's register. There will be eleven watertight compartments and a double bottom, and additional to the latter large tank space for the purpose of ballasting Cold chambers for the carriage of meat will have large capacity, an extensive refrigerating plant being installed.

Twin screws will be used, driven by quadruple-expansion balanced engines, with cylinders 28 1-2 in., 41 in., 58 1-2 in., and 84 in. dia. and 54 in. stroke, of about 10,000 collective horse power. Steam will be generated at 210 lb. pressure in nine single ended Scotch boilers, worked under the Howden system of forced draft. At sea a speed of 15 knots is designed for.

In the way of deck gear the *Saxonia* will be well equipped with steam capstans, warping and cargo winches, and steering gear.

The construction of these two vessels marks another step in the slow, but steady progress of this great line, as it will mean the introduction of the quadruple-expansion into its service on big ships.

The influence of the American built *St. Paul* and *St. Louis*—quadruple-expansion, Howden draft—is having its effect in transatlantic practice.

American Steam Yacht Eleanor

One of the handsomest of the large American steam yachts is the *Eleanor*, now owned by Mrs. J. W. M. Cardeza, of Germantown, Philadelphia. This fine sea boat recently arrived in the port of New York after an extended northern cruise. In July last the cruise began, and the first port of call after leaving New York was Newport, and afterwards Vineyard Haven, Nantucket, Portland, Rockland and Bar Harbor in succession. After touching in various places in the vicinity of Mount Desert Island the yacht sailed for Nova Scotian waters, calling at Digby, Halifax and afterwards at Sydney, Cape Breton, Charlottetown and Georgetown, P. E. I. A ten-day cruise through Bras d'Or lakes followed, and then a return was made to Sydney, C. B. for coal. From there the yacht sailed for Port au Basques, Newfoundland, where a hunting party made up from those on board spent two weeks ashore in the woods after caribou. The hunters were so successful that on the return voyage the yacht touched at Bangor, Me., and twenty-six fine caribou heads and hides were sent to be prepared for trophies. Mrs. Cardeza, who is a splendid shot, carried off the honors by bringing down the largest caribou on the trip. On October 15 last the *Eleanor* left the Bay of Islands, calling at various ports from Sydney, C. B., to those in the Sound, on the way to New York.

The *Eleanor* is an American yacht in the strict sense of the term. She was built about six years ago at the Bath Iron Works, Bath, Me., for W. A. Slater, of Norwich, Conn., who owned her until about fifteen months ago, when the sale to the present owner was made. The first voyage made by the *Eleanor* extended around the world, and since that time she has cruised in the fjords of Norway, in the Caribbean Sea and elsewhere, having steamed altogether about 80,000 miles. Mrs. Cardeza proposes soon to sail for an extended cruise in the Mediterranean.

A few particulars of the dimensions and equipment of this vessel will be of general interest. Her dimensions are as follows: Length, 234 ft.; beam, 32 ft.; depth, 17 ft. 5 in.; draft, 14 ft. 5 in.; gross tonnage, 803 tons.

VIEW OF STEAM YACHT ELEANOR OFF STARBOARD BOW.

She is built of steel, is bark rigged, and has a single screw driven by triple expansion engines, with cylinders, 18 in., 28 in. and 46 in. dia., and 30 in. stroke, indicating 1,100 horse power. Steam is supplied by two Scotch marine boilers, 11 1-2 ft. long and 12 ft. 5 in. dia., with six furnaces in all. There is a bunker capacity for 300 tons and fresh water capacity for 22,000 gallons.

Under steam (natural draft) a speed of about 14 knots is maintained, and with canvas alone and a good breeze the yacht will average 8 knots. She carries a crew of forty-four men all told, and Captain D. A. Weed, of Rockland, Me., is her skipper, and the machinery is under the supervision of Chief Engineer W. C. Bonning, of Brooklyn, N. Y. The *Eleanor* cost in the neighborhood of $300,000 ready for service, and the cost of maintenance is not far from $100,000 a year.

ENGINEERING IN THE UNITED STATES NAVY—ITS PERSONNEL AND MATÉRIEL.—I.*

BY ENGINEER-IN-CHIEF GEORGE W. MELVILLE, U. S. N.

In our society, the president has the widest latitude in the choice of a subject for his annual address, and, indeed, there is scarcely an established custom as to its nature; but it always seems logical for him to choose a theme connected with the work to which his life has been devoted, and in which he is an expert. This would make my subject, "Naval Engineering," and there are several reasons why it is particularly appropriate at this time. Although one other naval engineer has been president of the society, his address had a different theme, and consequently the subject, at least as a presidential address, will be new. Moreover, this year marks a very decided change in the personnel of engineering in our navy, so that it is particularly appropriate that one of the engineers of the old school should, at the close of this chapter in the history of naval engineering, give a brief review of some of its more important facts with respect to both personnel and matériel.

Every American is naturally proud of the fact that the first successful steam vessel was the work of an American engineer; but it is not so generally known that the first steam war vessel of any navy was designed by the same American (Robert Fulton) and was built in this very city in 1814. Had the war with England lasted a little longer there can be no doubt that the *Demologos* would have created a revolution in naval architecture; but the close of the war before she was completed rendered her active service unnecessary, and she was finally destroyed by an explosion of her magazine in 1829. The advent of the *Demologos* did not create an engineer corps, nor bring any engineers into the navy, so that the real beginning of naval engineering was when the steamer *Fulton* was built, and in 1836 Charles H. Haswell, the Nestor of engineering in this country, became the first chief engineer in our navy. The *Fulton* was a small vessel of only 1,200 tons displacement, or about what would now be considered a small gunboat; but she was the beginning of what has brought about as great a change in navies as the invention of gunpowder did in warfare.

It is really wonderful to think that the man who was the first chief engineer of this first steam war vessel of our navy is still alive, in full possession of his faculties, and in the active practice of his profession to-day. One of his contemporaries some years since said that the Engineer Corps might consider itself very fortunate in having had for its founder such a man as Mr. Haswell, an educated gentleman and a thoroughly competent engineer. From the very first his every effort was devoted to increasing the efficiency both of the machinery and of the officers who were to care for it, and it is not going too far to say that he has left a lasting impression by his labors, the organization and scheme of examinations having long remained as he made them.

It is a little hard for the young engineers of to-day, whose training, while it may seem to them beset with difficulties in the way of intricate formulæ and abtruse calculations, is nevertheless complete, and makes them masters of an immense amount of accumulated information, to realize the difficulties under which the older engineers, even of the writer's generation, and much more so of Mr. Haswell's, labored. Mr. Haswell himself was one of the first to provide a reliable book of

AMERICAN BUILT STEAM YACHT ELEANOR, OWNED BY MRS. J. W. M. CARDEZA, OF PHILADELPHIA.—SEE PAGE 78.

*President's address (1899) at New York meeting of American Society of Mechanical Engineers.

reference for the young engineer, where the results of experience were systematically arranged; but for Mr. Haswell himself there was nothing of this sort, and he had to create the precedents. When we look at the matter in this light, we are filled with admiration for Mr. Haswell and the men of his generation at their excellent solution of the problems which confronted them.

Without going into a detailed sketch of the work done by Mr. Haswell, it may not be amiss to recall to your minds a famous old ship, the machinery for which was designed by Mr. Haswell, who, indeed, made all the drawings for it himself. This vessel was the *Powhatan,* which for many years was one of the finest of our old ships and rendered most efficient service. Probably every member of the society living near our eastern coast has seen this fine old ship. She was built in 1847, and remained in active service for forty years, a monument to those who had designed and built her.

In those early days the average deck officer of the navy did not look upon the steam engine as a desirable addition to a ship, but simply as a necessary adjunct that had to be endured. There were, of course, notable exceptions, and Captain Matthew C. Perry, the first commander of the *Fulton,* was a liberal minded man to whom engineers owe a great deal. Yet, even he hardly rose to the point of considering that engineers were a vital part of the ship's complement, and as such should be made to feel that they were as much officers as any others, and their men were just as truly sailors. Neither Mr. Haswell, nor any of his assistants, were regarded, when first appointed, as permanently in the navy, and the assistant engineers were removable summarily by the commandant of the station. Some years ago Passed Assistant Engineer Bennett, writing for one of the reviews, in speaking of this circumstance, expressed surprise that the deck officers should not have realized the mighty force which steam brought to them and have embraced every opportunity to take advantage of it. It seemed, on the contrary, to belong to a different world from that in which they had been trained, and instead of endeavoring to become expert engineers, they regarded the machinery and all connected with it as a disagreeable necessity and left its development to the separate Corps of Engineers.

Among the older engineers were many men well known to all mechanical engineers in the country, who in a quiet way did very valuable work. Time will not permit, however, of mentioning them individually in such a survey as we are making.

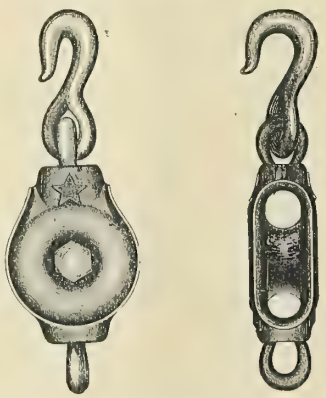
Some years before our civil war another great marine engineer began to attract attention—Benjamin F. Isherwood. He entered the navy in 1844, so that he is really a contemporary of Mr. Haswell. It is perhaps not exaggerating to say that he is the most brilliant marine engineer whom this country has seen, and his work has made his name known among marine engineers in all parts of the world. His fame will probably rest mainly on his record as an experimentalist, in which field there are few who have ever exceeded him, either in the amount or the excellence of the work done.

Preliminary trials of the U. S. torpedo boat *Goldsborough* 250 tons, at Portland, Ore., are reported to have turned out very satisfactorily.

IMPROVED APPARATUS.

Tarbox Tackle and Block.

A new style of tackle block has recently been patented by Alfred B. Tarbox of Boston, which is remarkably simple in construction, strong, and can be manufactured at less cost than the ordinary forms. The construction of this block, as will be seen by inspection of the accompanying sketch, gets rid of all rivets or pins other than the sheave pin or axle. The cheek pieces, which can readily be made by casting or stamping, are provided at the ends with lateral extensions projecting from the inner sides. When the cheek pieces are brought together these extensions interlock and the shell is formed. Suitable recesses are cast or stamped in the interlocking pieces at the ends for the reception of the shanks of the shackles, without the need of machine work. The cheek pieces are swelled inwardly at the centers, forming a boss or hub, with a plane face on the interior, against which the hub of the sheave bears. Through the center of this boss the sheave pin passes,



TARBOX PATENT BLOCKS.

being secured outside on each end by a lock nut. The nuts are sunk in the depression on the outside of the cheek pieces, and hence the block has practically a flush face at each side. The sheave pin not only serves as a journal but holds the frame or shell together. The edges of the cheek pieces are rounded inwardly so that chafing of the sheave rope is not possible. Blocks with more than one sheave are made on the same principle, with slight modifications in design. These blocks are now being manufactured by the Boston & Lockport Block Co., 142 Commercial street, Boston, Mass.

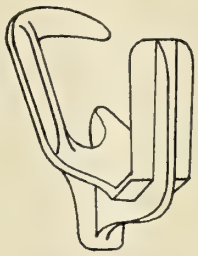
"Durable" Wire Rigging.

A cross section of the "Durable" wire rope presented in the engraving has a close resemblance to a section of submarine telegraph cable. This new style of rope, which was only recently patented and put on the market, differs from the ordinary wire rope in that each strand is separately served with fibrous material before the rope is laid up. By this means a rope is secured which has many of the qualities of the hemp or manila rope, while retaining the strength of the wire rope; and bulk for bulk the new rope is stated by the patentees to be from 7 per cent to 10 per cent stronger than

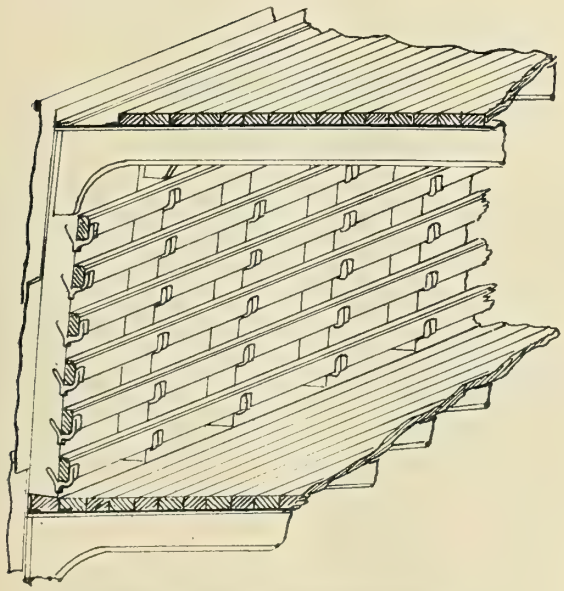
the ordinary wire rope, about 25 per cent. more flexible, and from three to six times as durable. Serious deterioration of the ordinary wire rope is caused by the wear of the strands against each other and against sheaves and drums in the case of running rope, while in the new rope the sheathing gives a cushioning ef-

"DURABLE" YACHT RIGGING.

fect and permits an even bearing of the rope against the surfaces over which it passes. In the case of standing rigging the protection of the wires from the action of the weather tends towards long life, and where the rope is used for towing hawsers or anchor roads, the



SINGLE CLEAT.



ATLEE BATTEN CLEATS IN POSITION.

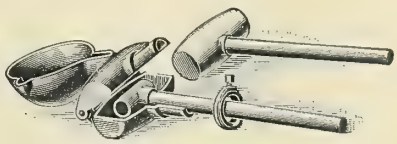
corrosive action of the water can be practically neutralized by saturating the covering with oil. The engraving shows the galvanized cast steel wire rigging manufactured for yacht and ship use. It is composed of five strands and a hemp center, with seven wires to a strand. The approximate breaking strain of a "Durable" rope of this style, 2 in. circumference, before serving, is 14 tons. As it is much lighter and smaller than ordinary galvanized rope of the same strength, it is specially recommended for yachts. The rope is manufactured by the John A. Roebling's Sons Co., for the patentees and proprietors, the Durable Wire Rope Co., 234 State St., Boston, Mass.

Cargo Batten Cleat.

In the engravings a new batten cleat is shown in position between decks, and also a single cleat. This is a cheap metal device, which is attached to the frame by simply drilling a hole for the hooked end to fit into. Those illustrated are for vessels with bulb angle frames, but another form is supplied for use in vessels with the ordinary frame and reverse frame. No tools are required to place the cleats in position. They are simply hooked in place and can be speedily removed at any time when the nature of the cargo demands this. This is one of the advantages of the Atlee cleat, for it can be used again and again. The cleats are made of either cast steel or malleable iron, and are practically indestructible. Joshua W. Atlee of Riverton, N. J., is the patentee.

Combination Mould and Handle.

This compact device enables the user to readily produce soft metal hammers for shop use, with the aid only of the metal and any convenient fire. The mould, as seen, is in two pieces, with the ladle attached to the upper half, the mould being closed ready for pouring by simply slipping the ring or dog over the end of the shank. The handle for the hammer is made of ordinary iron pipe, with a T piece on the head end. This is inserted in the mould, as shown, and when the ring is slipped in place, and the metal in the pot is melted, the mould is tipped up so that the metal flows down into



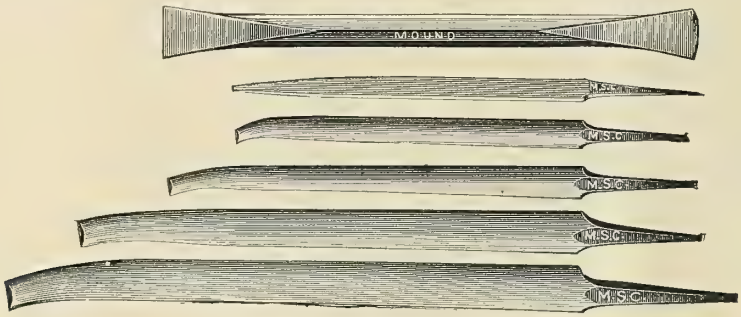
COMPOSITION HAMMER MOULDS.

the mould through an aperature in the top, filling up the space between the T piece and the inside of the mould. There is no possibility of the head of the hammer being jarred off by repeated blows in use, and the heads can be recast without delay when worn out of shape. The ladle is also fitted with a lip of the usual form, so that it can be used for other purposes. It is manufactured by Charles H. Field, 42 Point street, Providence, R. I.

Steel Scraping Tools.

In these days of precision in shop work the aid of all tools and appliances that will produce exact results, with the least expenditure of time, is called in by the en-

gine builder. As supplying a need in this direction, the Mound Tool and Scraper Co. has put on the market a set of scraping tools held in a neat oak case, so that they can always be found together in the tool room. The scrapers are made of the best tool steel, carefully forged, finished, and tempered, so that they are true in shape and possess the proper temper for effective work. This set is of special value for use in the marine engine room, where the scraper is indispensable, and where work has often to be done in haste, yet accurately, and there is neither time nor probably facilities for making the needed tools. In addition to this regular set the company also makes special sizes and shapes on order. Its address is 712 Howard street, St. Louis, Mo.



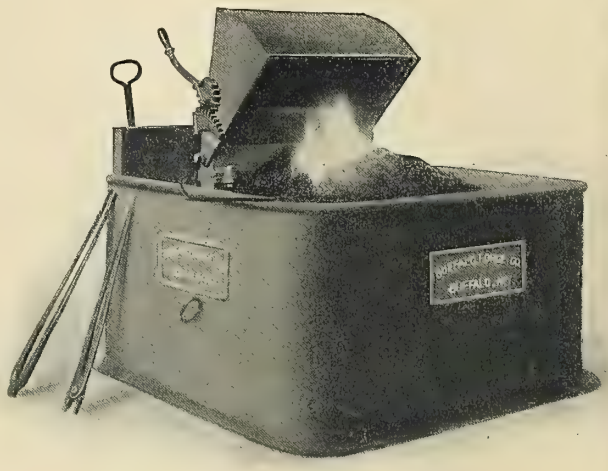
MOUND TOOL SCRAPER SET.

Down Draft Forges.

One of the most marked improvements in the equipment of blacksmith or angle smith shops is the substitution of down draft forges for the old fashioned fires with hood and vertical smoke pipe. The advantages of this modern system are many. No obstruction is offered to the handling of large or bulky material, and the use of overhead cranes is possible. There are no unsightly pipes to be taken care of, and as a consequence, the shop looks cleaner and can be better lighted; both items which contribute to the comfort of the men. Then the fouling of the air in the shops is avoided, as all smoke and gases are removed immediately on being generated at the fire, and carried through underground pipes to the point of exit. The system adopted by the Buffalo Forge Co., one of whose heavy forges is illustrated in the engraving, can be installed in two ways: First, with separate fans, that is a blower for furnishing the blast and an exhauster for carrying off the smoke and gases; second, with a combined blower and exhauster in which a portion of air is forced through the blast piping for supplying air to the hearth, and the remainder discharged into the smoke pipe, thus creating a strong draft. The forge shown is made exceptionally strong for engine or heavy ship work. Engineers who contemplate the location of new shops, or the extension or the modernization of old ones, can procure further information from the manufacturers, Buffalo Forge Co., Buffalo, N. Y.

Crank Shaft for Russian Cruiser.

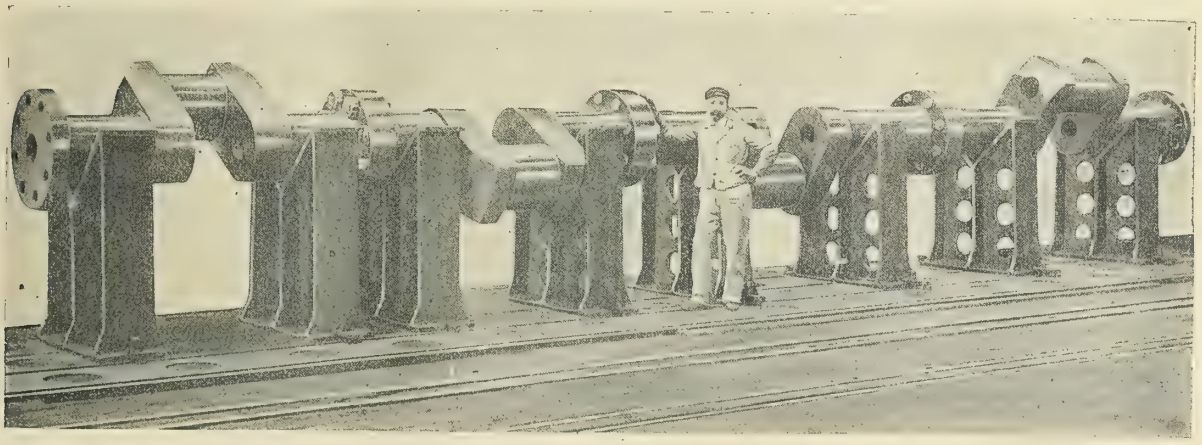
One of the four throw crank shafts for the Russian cruiser *Variag*, being built at Cramps, is shown in the accompanying engraving reproduced from a photograph of the crank in the shops of the makers, the Bethlehem Steel Company, before shipment to Philadelphia. The shaft is made of special open hearth shafting steel, and is guaranteed to possess an elastic limit of not less than 36,000 lbs. per sq. in., with good elongation. The forgings of which this is a type were produced under heavy hydraulic-presses at the Bethlehem plant, and, after being carefully annealed, were finish-machined complete and fitted together there as shown. They are similar to the shafts made by the same company for the Russian battleship *Retvizan*, both vessels being built at the Cramp yards in Philadelphia, as already noted. In addition to these forgings, the Bethlehem Works furnished all the straight shafts for both ships, together with the engine-columns, crossheads, piston-rods and connecting-rods, the last two being made of oil-tempered nickel steel, to give special physical qualities. All of this material was subject to the specifications and test prescribed by the Russian Marine Ministry, and was produced under the personal supervision of navy officers detailed by the Russian Government for this purpose, and who were stationed at the works. Such work as this is only another illustration of the confidence with which foreign governments regard American products. But although the work is of such high class, it may be said to be a matter of ordinary routine at the Bethlehem plant, which is equipped with such facilities as to enable it to meet successfully the most rigid specifications known to modern science.


BUFFALO DOWN DRAFT FORGE.

Coaling Vessels at Sea.

At the recent meeting of the Society of Naval Architects and Marine Engineers, a paper was read by Spencer Miller on methods of coaling warships at sea, in which the apparatus he had designed was explained. Our readers will recall the abstract of his paper published in the report of the meeting. Since that time further experiments have been carried out by the Navy Department, using this apparatus at sea off Sandy Hook, the collier *Marcellus* and battleship *Massachusetts* taking part in the trials. In the accompanying engraving the position of the vessels during the coaling operations is shown. They were at a distance of from 300 to 400 ft. apart, depending on the condition of the sea. On the collier there was mounted an engine with two drums or reels; a small wire rope, 3-4 in. dia. was led from one drum or reel to a sheave at the top of the foremast and thence across to a sheave mounted above the quarter deck of the warship, returning by a parallel route to another drum or reel. A load carriage of novel design gripped the upper branch of this elevated rope, and was forced to travel by the reciprocating motion of the rope to and from the warship. From the carriage were suspended two bags of coal weighing 840 lbs., and by disengaging gear these were dropped into a canvas chute over the quarter deck of the warship at the rate of one load per minute, or from 20 to 25 tons per hour. The rope was operated by one drum or reel winding in one end of the rope, while the other drum or reel was arranged to wind the rope and also to slip when needed. Thus one drum gave motion to the rope and the other kept the requisite tension in the rope while it was paying out, so that the coal bags were carried with sufficient clearance over the water. The supports for the apparatus were the foremast of the collier and shear poles on the *Massachusetts*, and these were held by steel guy ropes much stronger than the small wire ropes which carried the loads across. By the use of this conveyor if the boats lurch apart, one rope simply slips to accommodate it, and if the boats come together either one drum or the other winds it in at a speed faster than the ships can approach one another. The invention employs besides the conveying rope, an auxiliary rope known as the sea anchor line, which is solely employed to prevent the carriage from twisting when returning unloaded from the warship. This sea anchor line is secured by a lashing or knock-off hook to the warship and passes over a pulley on top of the carriage, from thence it is led through pulleys on the two masts and then astern several hundred feet into the sea. On its end is secured a canvas cone dragging with its mouth towards the warship and known as the sea anchor. The apparatus employed in these tests was manufactured by the Lidgerwood Mfg. Co., New York.

TEST OF MILLER COALING APPARATUS AT SEA.



FOUR-THROW BETHLEHEM STEEL CRANK SHAFT FOR RUSSIAN CRUISER VARIAG—SEE PAGE 82.

MARINE ENGINEERING

PUBLISHED MONTHLY

BY

ALDRICH & DONALDSON,

309 Broadway, New York.

Editorial Department,
H. F. DONALDSON.

Business Department,
H. L. ALDRICH.

Branch Offices,

Detroit, Mich., Hodges Building, L. L. CLINE.
Chicago, Ill., Monadnock Block, S. W. HUME.

Special Representative,

L. H. ELLIOTT.

TERMS OF SUBSCRIPTION,

	Per Year.	Per Copy.
United States, Canada, and Mexico.....	$2.00	20 cents.
Other countries in Postal Union....	2.50	25 cents.

Entered at New York Post Office as second class matter.

Notice to Advertisers.

Copy for changes in advertisements must be in our hands not later than the 20th of the month to insure changes being made in the issue of the month following, and not later than the 15th of the month if corrected proof is to be submitted.

AMONG persons interested in shipping, more especially, the action of Congress in the matter of ship subsidies is awaited hopefully, with the expectation that the development of our merchant marine will receive adequate treatment. Our mission is not political; but as the subject is really commercial rather than political, we offer no excuse for this reference. Indeed, there is no subject occupying the minds of public men to-day which, in our opinion, is of more vital consequence, or likely to cause progression or retrogression of the country as a commercial nation, than the expansion of the American merchant marine. Our opinion as to the best course to be pursued has already been stated—a thorough and impartial investigation of the subject as a whole by a competent commission, and united Congressional action when a correct judgment has been reached. Probably this would be expecting more than the attainable, for there is a manifest desire in influential quarters to make political capital out of the whole subject, and, in fact, to make it a party measure. Sectional differences of interest are already being worked on to obstruct any measure that will make the American flag known in parts of the earth which have long since forgotten its colors. It is unfortunate that the question of Federal aid can be readily placed before the uninformed—by those who know better—in such a light that it looks like an attempt to benefit the few at the expense of the many. The great bulk of the population is inland, far removed even from the sight of an ocean and with immediate interests that take attention and effort away from things maritime. But even proximity to the sea has not, in many instances, increased the knowledge of those who treat of this subject; or is it that knowing the truth they desire to conceal it in a non-conducting covering of words for partisan purposes? Honest discussion seldom forms part of the procedure of practical politics. At any rate, it is remarkable how little in the way of real argument against Federal aid has been advanced on the platform or in the press. There are denunciations and criticisms in plenty, but no statements of any practicable alternative. None of the academic authorities has yet shown how freight can be carried competitively in American bottoms, under existing conditions in the world-wide trade. For example: placing an American and a British vessel of exactly the same type and dimensions alongside the same wharf, we find the former vessel represents a much larger original investment, and the operating expenses very greatly in excess of those for the British ship. How then is it possible for the American owners to charge the same rates and exist? American genius has not yet evolved any magic method by which a vessel can be propelled without the consumption of fuel and stores, nor has any means been devised whereby a skipper can touch a button and the vessel does the rest. It still requires the intelligent co-operation of a number of highly skilled men to get a steamship from one port to another, and these men are entitled to a wage equivalent to that enjoyed by those of the same capability or responsibility ashore. This seems a very simple statement, but it is one that is too often ignored, and it is the key to the situation. It ought not to be a necessity at the close of this century to point out to those in high places the tremendous benefits which result to a country from the possession of an adequate merchant marine. If no higher argument will prevail, the vast sums of money annually paid out by Americans to stockholders in foreign steamship corporations for the conveyance of American goods should be sufficient reason for action. In argument, or rather misstatement, a comparison is frequently made between shipbuilders and loco-

motive builders as to their ability to meet foreign competition. As to that, the locomotive builder has only reached his present position by the skill which the vast numbers of machines he has turned out has compelled. He has not only built engines in units but in tens, and to a great extent in duplicate orders, and has thus reached a condition of standardization unknown in shipwork. Again, the American type of locomotive is peculiarly adapted to service in "new" countries. In the case of ships there are no "new" seas for which we can specialize, there is little or no uniformity in type or duplication of orders, no standardization, and, more important than all, no continuous flow of orders that would warrant the investment of vast sums in special tools and special stock. Exceptions to this can be found on the Great Lakes, but those interests are outside this discussion.

BRITISH shipbuilding returns for the year 1899 show an increase over the figures for 1898; the respective totals being in round numbers, 1899, 1,650,000 tons, and 1898, 1,600,000 tons. These figures include all steam and sail tonnage launched from private yards. To this, therefore, must be added the vessels launched from the navy yards nearly 70,000 tons, to get the grand total for the year. Of the year's total about 350,000 tons were for foreign owners, our contribution to this total including the U. S. S. *Albany*, 3,700 tons, launched by Armstrong, Whitworth & Co., at Newcastle-on-Tyne, January 14, 1899. Engineering returns show that the output of propelling engines exceeded 1,500,000 indicated horse power. An inspection of the reports which make up the totals show that many vessels of the largest size were constructed, and that a large proportion of the big ships were for regular steamship lines. Largest of all was the *Oceanic*, and others of the first rank were the *Saxonia* and *Ivernia*, 15,500 tons, for the Cunard line, the *Bavarian*, 10,370 tons, for the Allan line, the *Saxon*, 12,970 tons, for the Union (South African) line, and two Castle liners (South African) of 10,000 tons each. There were in all sixty vessels built with a tonnage exceeding 6,000 tons. At the head of the list in tonnage launched comes Harland & Wolff, of Belfast, Ireland, with a total of 82,634 tons. Among the Scotch yards Russell & Co., of Port Glasgow, who were at the top of the list in 1898, again came out first with 52,400 tons. English builders were headed by William Gray & Co., Ltd., of the East Coast, with 77,500 tons, who the previous year had the largest output of any builder to their credit. Sail tonnage formed only a very small proportion of the total output, less than 40,000 tons.

TWO important meetings of engineering societies were held in Washington last month, each representing the engineering interests of the Navy and Merchant Marine respectively. On January 8, the American Society of Naval Engineers held its annual meeting, at which the election of officers for the following year resulted as follows: President, Commander Harrie Webster; Secretary-Treasurer, Commander G. S. Willits; Members of Council, Lieutenant Commander F. H. Bailey, Lieutenant B. C. Bryan and Lieutenant R. G. Griffin. An increase in membership was reported. In the competition for the prize essay the first prize (gold medal) was awarded to William F. Durand, of Cornell University, and the second prize to B. C. Ball. At the annual convention of the Marine Engineers' Beneficial Association, held later in the month, there were more than fifty delegates present. The national officers for 1900 elected were: National President, George Uhler, Philadelphia, Pa.; National Vice-President, Frank A. Jones, Alameda, Cal.; National Secretary, George A. Grubb, Chicago, Ill.; National Treasurer, Ed. R. Blanchard, Detroit, Mich.

READING the report of Captain G. W. Pigman, commander of the late U. S. cruiser *Charleston*, which narrates the circumstances attending the loss of that vessel, we felt that it is almost worth the loss of a ship to demonstrate the kind of stuff the personnel of our Navy is made of. In time of naval war it is to be expected that every man will do his duty, and the stir and fever of battle nerves many a man to more than ordinary human effort. It is when sudden and unexpected disaster rushes a man face to face with death that his real qualities and the results of his training are shown. In this generation there have been many sore trials of American naval valor in peace time, at Samoa, at Cuba, and now at the Philippines, and in each case the real grit of our Navy has been shown.

EDUCATIONAL DEPARTMENT.

HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—BOILERS—IV.

BY DR. WILLIAM FREDERICK DURAND.

§3. CORROSION.

No sooner has a boiler been completed than the various corrosive and destroying influences with which it is surrounded set to work on its destruction. We may conveniently consider corrosion as of two kinds, that due to oxygen and that due to an acid. These two are, however, by no means independent, and are often combined in very complex ways. The process by which oxygen combines with another substance is called *oxidation*, and the product of the operation an *oxide*. In the case of iron and steel the typical product is the ordinary red iron rust, or ferric oxide (Fe_2O_3), consisting of about 56 parts by weight of iron and 32 of oxygen. In order that oxidation or rusting of iron may continuously proceed at ordinary temperatures, however, it is not enough that oxygen and iron shall be in contact. It requires the additional presence of moisture and carbon dioxide (CO_2), small proportions of which are always present in the atmosphere. Oxygen and moisture alone act feebly and very slowly on iron, but when the four substances, iron, oxygen, moisture, and carbon dioxide, are all present together, the operation of rusting proceeds continuously and with vigor. Oxide is first formed, and this is reduced by the carbon dioxide to a carbonate, and this in turn breaks up forming hydrated oxide ($FeHO_2$), setting free the carbon dioxide to continue the process. The hydrated oxide thus formed is furthermore electro-chemically negative to iron, and thus helps on the operation as explained at a later point. If either the moisture or the carbon dioxide is absent the oxygen will have little or no effect, and the iron will be protected. This is shown by the non-rusting of iron in perfectly dry air, even though there may be some carbon dioxide present; or again, by its preservation in a weak alkaline liquid, as lime water, in which there can be no free carbon dioxide. The piano wire used in certain forms of deep sea sounding apparatus, for example, is thus kept from corrosion under conditions which would naturally soon destroy its regularity and value for the purpose used.

Acid corrosion means the attacking of a substance by an acid, the breaking up of the latter, and the formation of a new substance known as a *salt*, and composed of a part of the acid and of the substance attacked. Thus hydrochloric or *muriatic* acid (HCl), as it is commonly called, is sometimes present in boilers. This is composed of hydrogen and chlorine. When it is brought into the presence of iron or steel the chlorine leaves the acid, and joining with the iron, forms a salt known as ferrous chloride, or chloride of iron ($FeCl_2$). With iron rust and muriatic acid the result would be similar, the chlorine would join with the iron and form ferrous chloride, while the hydrogen of the acid would join with the oxygen of the oxide and form water.

As before stated, acid corrosion and oxidation are very commonly both present, especially in the latter operation, and in fact the continued operation of oxidation with iron, moisture and carbon dioxide is dependent on the combined action of both operations. We shall not, however, deal further with the chemical details of corrosion in general, but proceed to a brief consideration of the causes, effects and remedies as related to corrosion in marine boilers.

Taking first the exterior of boilers and of all exposed iron and steel work in general, it is clear that the conditions for continued rusting are all present on board ship. The air is moist and there is likely to be present carbon dioxide in abundance. The only safe protection is, therefore, a covering which shall keep the air moisture and carbon dioxide from contact with the iron. To this end metal paint or other equivalent coating is used wherever possible. Many small fittings, especially about the deck, are of galvanized iron, that is, iron covered with a thin coating of zinc. The latter metal is but slightly affected by the process of oxidation, and it therefore forms an efficient protection for the iron. Brass, bronze and copper are also oxidized but slightly, and the oxide formed serves as a protective covering to the metal underneath. For this reason, among others, many of the fittings about boilers and elsewhere are, as we have already seen, made of these metals.

Passing in now to the fire side of the boiler, we find the application of paint or other protective coating impracticable. Here we must depend on the heat, which will so dry the air that it is no longer moist. That is, while water vapor may still be present in the air, there is so little compared with the amount the air could naturally contain at that temperature, that it is held by the air and is no longer free to enter as a factor into the operation of oxidation. Rusting in the usual way is, therefore, very much retarded or prevented. To this fact we owe the general preservation of the furnaces, ash-pits, etc., from serious and continuous corrosion. We here, however, run into another danger in the extreme case when oxygen is present in excess, and both the oxygen and iron are very hot. The oxygen in such cases enters more readily into union with the iron, and if the temperatures should be sufficient, a different kind of oxide is formed, the black, or magnetic oxide (Fe_3O_4), the same as the mill scale or forge scale, which forms when iron is worked at a red heat. The oxide thus formed may presumably be swept away by the scouring action of the draft, thus exposing a fresh surface to renewed attack. The back ends of the tubes seem especially liable to attack in this way, and particularly with hard forced draft. The cure for this trouble is found in the use of cast iron ferrules, as previously described.

These ferrules protect the tube ends from the extremes of temperature, and also provide something for the hot oxygen to attack, while they are readily renewed.

Turning now to the water side of the boiler, we find more serious trouble than with the fire side. There is likely to be more or less air in the feed water, either entering with the make-up feed, or occasionally drawn into the feed-pump and sent on to the boiler. There may also be free carbon dioxide liberated from the salts entering with the make up feed, and thus all the conditions for continuous rusting may be present. Even if free carbon dioxide is not present the formation of iron oxide, combined with electro-chemical reactions, as referred to later, may result in serious local corrosion.

Furthermore, as the feed-water is heated the air is liberated, and the oxygen just at the instant of liberation seems to be especially active chemically, and is thus all the more likely to attack exposed places than if allowed to remain in solution in the water, as at ordinary temperatures.

Turning next to acid corrosion, mention may first be made of the serious trouble formerly experienced from the use of animal and vegetable oils for cylinder lubrication. Such an oil is a compound of a fatty acid and glycerine. When exposed to a high temperature the fatty acid and the glycerine become separated. If a substance such as soda or potash is present, the fatty acid combines with it and forms soap. This process is called saponification. If, however, no such substance is present the acid will be free to attack other substances as it may be able. Fatty acids attack iron feebly, but if long continued the result may be a serious corrosion, resulting in the formation of what is known as an iron soap. The temperature within the cylinders and boilers was quite sufficient to thus decompose the oil, and there would, under such circumstances, be set free in the boilers an amount of fatty acid depending on the amount of oil used in the cylinders and finding its way into the condenser and feed-water. There were thus present all the conditions necessary for the corrosion of the interior of boilers by fatty acids, and many serious cases were laid, in part at least, to this cause. These troubles appeared especially with the introduction of the surface condenser, and the part which fatty acids might play being understood, the use of animal and vegetable oils for the lubrication of the cylinders was abandoned, and in their place hydrocarbon or mineral oils are now used. Such oils are derived as one of the constituents of crude petroleum, and are not compounds of a fatty acid and glycerine. They are compounds of carbon and hydrogen, and belong to an entirely different class of chemical substances. They do not produce a fatty acid on being heated, and cannot, at least directly, take part in the process of boiler corrosion.

In modern practice, therefore, nothing but the best hydrocarbon oil, entirely free from animal or vegetable admixture, should be used for cylinder lubrication. With lubricant of this character modern boilers should be free from corrosion chargeable to the action of fatty acids.

These are, however, not the only acids which have given trouble in the way of boiler corrosion. Under certain circumstances free hydrochloric or muriatic acid is found in boilers. This is presumably due to the breaking up of magnesium chloride, forming hydrochloric acid and magnesium hydrate. The most dangerous feature of the corrosion due to hydrochloric acid is that under conditions which may exist within steam boilers the chloride of iron first formed may become broken up, giving rise to other neutral compounds of iron, and setting free the acid to continue its ravages.

There are also possibilities of the development of nitric acid from the organic matter which in small quantities may occasionally find its way into steam boilers.

Except as it may be modified by electro-chemical action, the presence of such an acid usually results in a general surface corrosion, at least of all surfaces not protected by a sufficient layer of lime scale.

The most troublesome feature of boiler corrosion has not been, however a general or more or less uniformly distributed effect, such as would naturally be charged to the action of an acid diffused throughout the boiler. It has been rather in the so-called *pitting*. This term refers to the formation of small pits or depressions from the size of a pin head upward, and conical or cup-shaped in form. The depth of such pits may be anything from a slight depression to a hole cut entirely through a boiler tube. They are found in no fixed locality, though more commonly on the tubes, furnaces, and combustion chambers than elsewhere. When found they are usually filled with a blackish or brownish pasty mass, consisting chiefly of iron oxide with a slight admixture of lime salts, oily matter, and other substances. This deposit within the pits is often covered with a skin of somewhat different composition, consisting of lime salts and iron oxide in more nearly equal proportions.

To account for the formation of these pits, various explanations have been suggested, most of them involving *electro-chemical* action as a more or less pronounced feature. To understand the nature of this action a few explanations must first be given.

Nearly all substances are in a different electrical condition, or at a different electrical *potential*, as it is called. This difference is found not only between substances of different kinds, but also between similar substances at different temperatures, or in different physical conditions, as, for example, between two pieces of iron or steel, one of which has been hammered or worked more than the other. Due to this difference of electrical potential there is a tendency to set up a flow of electricity from one to the other, and as a further result to so change the two substances as to bring them into electrical equilibrium. In other words, the result of such a difference of electrical condition is always to bring about changes which will cause the difference to disappear, and so bring the two substances into equilibrium. These chemical changes of the two substances, which tend toward electrical equilibrium, may be much helped or hindered by the medium in which the bodies are immersed. If they are in dry air, for example, no such activity takes place, and the difference of electrical condition continues unchanged. If, however, they are immersed in water, or especially in salt or slightly acid water, the operation will usually be much assisted by the activity of the medium for the substances. It may also happen that the medium and substances are so related as to bring about a series of chemical changes, of which the first are those which would naturally be associated with the transfer of electricity and the development of equilibrium, while the second counteract these changes chemically, and bring the substances back to their original condition, and so keep them constantly in the condition of electrical difference. There is as constantly the attempt to restore equilibrium, and hence so long as these conditions continue there will result this continued series of chemical actions, accompanied by a constant flow of electricity from one substance to the other. In order, however, that this flow of electricity may be thus constant and so constitute a *current* of electricity, as it is termed, there must be a path for a complete circuit or flow in one direction through the medium which produces the chemical changes, and in the other direction outside of this medium. The substance from which the current flows in the medium is known as the

electro-positive element, and the other the electro-negative. The chemical activity proceeds and the current is formed, in general, at the expense of the electro-positive element.

These operations are illustrated in the ordinary voltaic cell or battery, such as those used for ringing bells, etc. In most of these batteries, however, the action is not self-sustaining, and if allowed to continue for a little time, a condition of electrical equilibrium is reached, or, as ordinarily stated, the battery is run down. In others used for telegraphy and other purposes the operations are self-sustaining and continuous until the chemical substances are exhausted.

In a boiler these conditions for a more or less continued electro-chemical action may be fulfilled in a variety of ways. Parts of the structure of widely differing temperatures or of different physical or chemical compositions may provide the elements in a different electrical condition. Still more likely is such a difference to be found between iron and its oxides, especially the magnetic oxide or mill scale (Fe_3O_4), or between a particle of carbon in the steel and the surrounding metal, or between a place in the steel where the proportion of carbon is much greater than the average and the surrounding metal, or between a bit of slag or other impurity in wrought iron and the surrounding metal. Copper, either in the form of oxide, or especially in the metallic form, would also supply a substance differing strongly from the iron. The exciting liquid is the water in the boiler, and its action will be more vigorous according as it is more acid in reaction, higher in temperature, and denser in concentration. With a high pressure boiler, water of high density and quite acid in character, and with the usual lack of homogenity or uniformity in the structure of the boiler, we should therefore expect the effects of electro-chemical action to be shown in marked degree. It happens, furthermore, that iron is electro-positive to copper, to carbon, and to its own oxides, so that in all cases likely to occur the operation will proceed at the expense of the iron.

From the very nature of these electro-chemical actions their effects are necessarily local in character, and so far as understood they seem to provide a fairly good explanation of the formation of pits as already described. It is not unlikely, however, that in some cases they are due rather to simple chemical action, and that their localization to a small spot is due to special or accidental causes, such as the protection of the surrounding metal by lime scale, or a peculiar weakness against chemical attack at that point, due to peculiarities in chemical or physical structure.

The naval Board of Construction has refused to recommend the purchase of the submarine boat *Holland* by a vote of four to one. Recently a board of survey which examined and tested the boat recommended not only the purchase of this boat by the Navy Department, but the construction of others of the same type.

Reports of the recent trials of the Parsons turbine driven torpedo boat destroyer *Viper*, published in the London *Times*, claim a mean speed of 34.8 knots for four consecutive runs over the measured mile. The fastest run is reported to have been made at the rate of 35 1-2 knots.

ELECTRICITY ON BOARD SHIP—PRINCIPLES AND PRACTICE—XXI.

BY WM. BAXTER, JR.

METHODS OF DISTRIBUTION.—CONTINUED.

In this article we propose to show how to calculate the size of wire for distribution circuits, and also to explain the advantages to be derived from certain arrangements of the connections. Suppose we have a generator that can deliver at its terminals a pressure of 110 volts, then if we connect an incandescent lamp designed for this voltage directly across the terminals it will be traversed by the proper amount of current, and will give the intensity of light at which it is rated. A lamp of this voltage, of 16 candle power, will require a current of about one-half of an ampere, therefore the resistance of it must be 220 ohms, for the e. m. f. is equal to the resistance multiplied by the strength of current, and one-half ampere multiplied by 220 ohms is equal to 110 volts.

Suppose now that we desire to supply another lamp with current, and that this is located 1,000 ft. (this distance is used for convenience of illustration) from the generator, the question is: What size wire must we use to obtain the necessary voltage at this last lamp? In the first place we must observe that it is an impossibility to obtain the full pressure of 110 volts at the distant lamp, but we can come as near to it as is necessary to get an illumination from the lamp practically the same as that of the one connected across the terminals of the machine. To obtain a satisfactory light we must have at the distant lamp a pressure of not less than 105 volts, so that we can lose 5 volts in overcoming the resistance of the line wires. As the lamp is at a distance of 1,000 ft. there will be 2,000 ft. of wire through which the current must pass, and the current strength for one lamp being one-half on an ampere, the resistance of this 2,000 ft. can be 10 ohms, or at the rate of 200 ft. per ohm. Looking at a table of resistances we will find that the nearest number to this is No. 17 B. & S. gauge, which runs about 198 ft. per ohm. Thus we find that to operate one lamp at 1,000 ft. from the generator we will require wires of No. 17 gauge. If we desire to operate ten lamps the current required will be 5 amperes, and then the resistance will have to be reduced to 1 ohm, for the loss of voltage can only be 5 volts, no matter what the number of lamps may be. Looking again at the table of resistances, we will find that No. 7 wire runs about 2,017 ft. per ohm, hence this is the size wire we require.

Tables that give the diameter of wire for all the gauge numbers, and also the resistance per foot, or the number of feet per ohm, are very numerous and easily obtained from any supply house. Like numerous other things, however, they are not always at hand when we want them, therefore it is well to have some simple rule by means of which we can determine the resistance of a wire if we have no table. If we are provided with a micrometer gauge we can find the resistance very nearly by simply squaring the diameter of the wire, measured in hundredths of an inch, and adding one cipher to the result. As an example, take No. 10 B. & S. wire, the diameter of which is nearly 10.2 hundredths

of an inch, and this number multiplied by itself is equal to 104.04, and by adding one cipher we get 1,040 as the number of feet per ohm. The actual number of feet as given in the table is 1,055, so that the difference is on the safe side. Number 0000 wire is forty-six-hund-

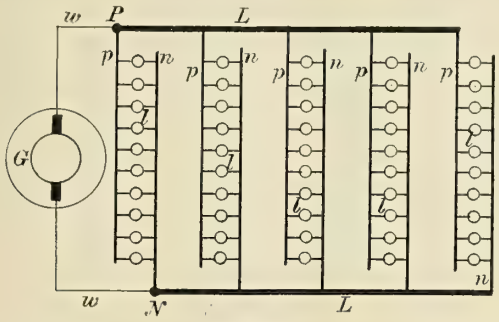


FIG. 134.

redths of an inch diameter, hence 46 × 46=2,116, and by adding one cipher we get 21,160 feet per ohm, and the numbers given in the table are 20,497.

If we are not provided with a micrometer we can still determine the feet per ohm if we know the gauge number of the wire, for the relation between the sizes is such that for every three numbers the cross-section

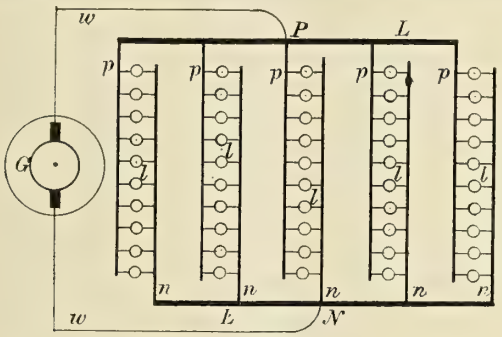


FIG. 135.

is about doubled; hence the number of feet per ohm is doubled, therefore all we have to do is to remember the resistance of three consecutive members, and from this we can determine the feet per ohm of any size. No. 10 wire runs 1,055 feet per ohm; No. 9 runs 1,268 feet, and No. 8 runs 1,600 ft. No. 11 is double the re-

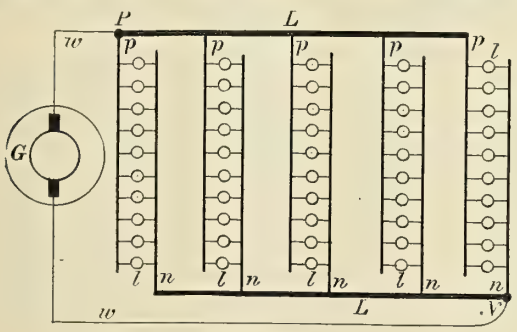


FIG. 136.

sistance of No. 8, or 800 ft. per ohm. No. 13 is double the resistance of No. 10, or 525 feet per ohm, and No. 7 has one-half the resistance of No. 10, or 2,110 ft. per ohm. These figures are not strictly accurate, but near enough for most practical purposes.

Figs. 134 to 138 illustrate different ways in which the lines may be connected, and as will be seen from what follows, they do not all require the same amount of wire to transmit a given amount of current. In Fig. 134 the generator terminals are shown connected with the left hand ends of the line wires *L L*, between which five sets of lamps are connected. As there are ten

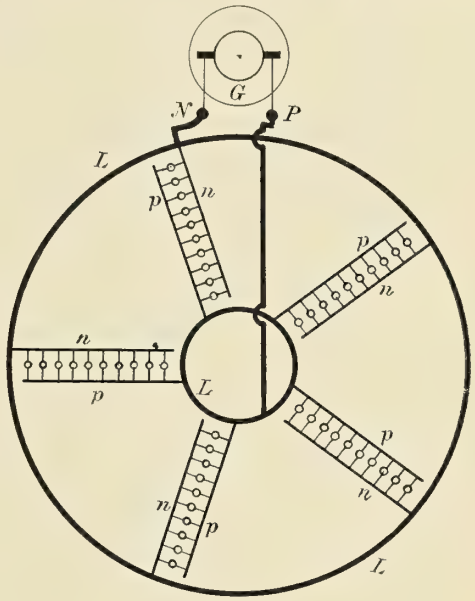


FIG. 137.

lamps in each group the current will be 5 amperes, or 25 amperes for all the lamps. Let the length of lines between the lamp groups be equal, and let the pressure at the generator terminals *P N* be 110 volts; let the resistance of each line *L* be ten-hundredths of an ohm; then, as the first group of lamps takes 5 amperes there will be 20 amperes passing to the second one, and as

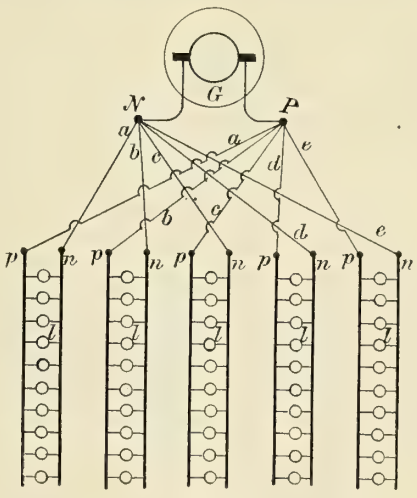


FIG. 138.

one-quarter of the length of each line is traversed before reaching the second group the voltage lost in overcoming the resistance to this point will be 20 amperes multiplied by five-hundredths of an ohm, which is equal to one volt. Thus we find that the e. m. f. at the second set of lamps is 109 volts. The current passing

to the third set of lamps is only 15 amperes, and as the resistance is the same as between the first and second groups the voltage drop will be three-quarters of a volt, therefore, the e. m. f. at the third group will be 108.25 volts. The current passing from the third to the fourth group will be 10 amperes, and the loss of pressure will be one-half of a volt, hence, at the fourth group the e. m. f. will be 107.75 volts. The current passing from the fourth to the last group will be 5 amperes, and the drop of pressure will be one-quarter of a volt, therefore, at the last group of lamps the e. m. f. will be 107.50 volts.

Now let us see what effect the arrangement of the connections shown in Fig. 135 would have upon the loss of voltage. Here the generator terminals are at the center of the mains *L L*, therefore the central, or third group, will receive the full pressure of 110 volts. As 5 amperes of current will pass through this group, there will be 20 amperes left, and this will divide into two equal parts, one of which will flow to the right toward group four, and the other to the left toward group two. These currents being of 10 amperes will lose a pressure of one-half of a volt in passing to the second and fourth groups, as the resistance of the mains between these points is five-hundredths of an ohm. The pressure at the second and fourth groups, therefore, will be 109.5 volts. The current passing from the second to the first group, and from the fourth to the fifth, will be 5 amperes, therefore the drop in pressure will be one-quarter of a volt, thus giving the e. m. f. for the first and last groups equal to 109.25 volts.

In Fig. 134 the voltages of the five groups of lamps are 110, 109, 108.25, 107.75 and 107.50. In Fig. 135, with the same size main feeders *L L*, the voltage at the center group is 110, and at the second and fourth groups it is 109.50, while at the first and fifth it is 109.25. From this it will be seen that if the generator terminals are connected to the center point of the mains *L L*, the drop of voltage will be decidedly less, if the same size wire is used, or, if we do not desire to reduce the drop of pressure we can reduce the size of the mains.

In Fig. 136 the generator terminals are connected with opposite ends of the mains *L L*, as can be seen from the position of *P* and *N*. From *P* the current can pass directly to the first group of lamps, and from *N* it can pass to the last, or fifth group, therefore the number of amperes flowing back from *N* toward the first group will be 20. Of this amount 5 amperes will pass to the fourth group, leaving 15 amperes to pass to the third one. As this last-named group will take 5 amperes, there will be 10 amperes to pass to the second group, and from here 5 amperes will go to the first group. The resistance of each line *L* being ten-hundredths of an ohm, the quarters between the several groups of lamps will have a resistance of two and one-half hundredths of an ohm. Thus the drop of pressure from *N* to the fourth group will be half a volt, and from the fourth to the third group it will be three-eighths of a volt, and from the third to the second one-quarter of a volt, while from the second to the first group the loss will be one-eighth of a volt. Adding all these drops we get 1 1-4 volts drop between *N* and the first group of lamps; hence the pressure delivered to these will be 108.75 volts, and this same voltage will be delivered to the fifth group, for the current passing from *P* to the last group will lose just as much pressure as that passing from *N* to the first group, since both currents are the same.

The current from *P*, that passes to the second group of lamps, is 20 amperes; hence the drop between these points is ½ a volt, but the current passing from *N* to the second group only loses 1⅛ volts, as shown in the last paragraph, therefore the total loss of pressure for the second group is 1⅝ volts, giving the e. m. f. for this group as 108.375 volts. As can be readily seen, this is also the voltage that acts upon the fourth group.

The third group will have a pressure of 108.25 volts, for there will be a drop of ⅞ volt from *P* to the top of this group, and also from *N* to the bottom of it. The loss of pressure with this last arrangement is greater than in Fig. 135, but less than in Fig. 134; hence, for the same loss of pressure the wire would have to be smaller than in the arrangement Fig. 134, but larger than in Fig. 135. In the last figure the pressure of the center group is 110 volts, and that of the end groups is 109.25, thus making a difference of 3-4 volt between the extreme pressures acting upon all the lamps. In Fig. 136 the highest pressure is 108.75 volts, and the lowest 108.375, making the difference between the extremes ⅜ volt, or just one-half as much as with Fig. 135. From this it will be seen that the last figure shows an arrangement that gives a more nearly equal pressure at all the lamps, but it requires a little more wire to keep the total loss of pressure down to the same point.

Fig. 137 represents an arrangement that differs from those shown in the previous figures, in that the mains *L L* form closed loops. If the currents tap into each main at diametrically opposite sides of the diameter we have simply an extension of the plan shown in Fig. 136, while if they cut in on the same side the arrangement amounts to the same thing as Fig. 135. The advantage over both these figures is that if a number of lamps are turned on or off in any group the change in the pressure will not be so great, since the current can reach any group by running around the looped main in either direction, as the case may require.

Fig. 138 shows an arrangement in which each group of lamps is fed directly from the generator terminals. In this case each group receives the same voltage, and as they are all independent, increasing or decreasing the number of lamps in any one group, does not in any way affect those in the other groups.

If we desire to run all the lamps all the time and wish to supply them with as nearly a uniform pressure as possible, but are not particular as to the loss in the transmission lines, then the plan shown in Fig. 136 will give the best results, for with the same amount of wire the difference in voltage at the several groups is the smallest. If the lights are to be turned on and off whenever necessary, the plan of Fig. 135 will be the best, for with it the total loss of pressure is the least with a given size of wire, although the difference between the pressures of the several groups is greater.

A modification of Fig. 138 is shown in Fig. 139, in which feeders are run from the generator terminals to different points along the distributing mains. When this arrangement is used it is possible to deliver a higher voltage to the distant lamp, if so desired, than to

the nearby ones by simply making the feeders *a b c* of different sizes, *c* being larger than *b* and *b* larger than *a*. We can also introduce special regulating devices for the

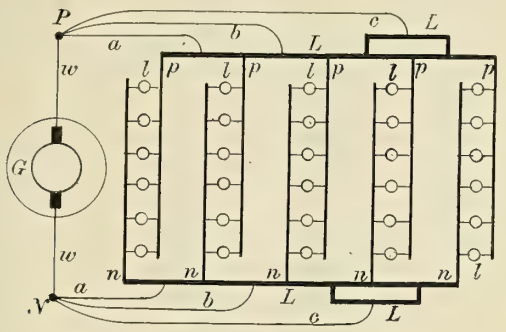


FIG. 139.

purpose of maintaining a uniform pressure, but this part of the subject we will defer to the next article.

POCKET BOOKS FOR 1900.

Fowler's Mechanical Engineers' Pocket Book for the year 1900 has just been issued by the American publishers, D. Van Nostrand Co., New York. This is, we believe, the second year of publication, and the experience gained with the first issue has been used to advantage in making the present issue more complete and useful as a book of reference. The book covers a wide range of subjects, as its name would indicate. An apparent effort has been made to simplify the contents, as far as consistent with a pocket book presentation of the subject; and a feature of the work is the use of explanatory paragraphs throughout in which the present state of knowledge, or the commercial application of it, in each case, is concisely stated. Besides the usual contribution of working formulæ and tables there is a table of properties of saturated steam over a wide range of pressures, from 1 lb. to 300 lbs. absolute pressure. Chapters are devoted to steam boilers and engines, gas and oil engines, locomotives, machine tool work, hydraulics, textile machinery, building, construction, metallurgy, mining, etc. A very considerable amount of space is devoted to electricity, with special reference to electric traction, and there are small chapters on such subjects as chains, springs, acetylene and chemistry. A special chapter on the construction of steamships is written by James Wimshurst, formerly connected with the British Board of Trade. Considering the size of the book, about 500 pages, and the variety of subjects covered, it is well worth the investment of $1 as an addition to the stock of available data on the designer's shelf.

Probably the lowest-priced book issued anywhere for engineers is the Mechanical World Pocket Diary and Year Book for 1900, published by the *Mechanical World*, Manchester, England, price 6 pence. Although published at such a low price, the book is printed in good style. It contains chapters devoted to steam and the steam engine, gas engines, boiler construction—though this refers to tank boilers exclusively—beams and girders, shafting and gearing, belting, electrical transmission of power and hydraulics. There are also included a number of useful tables.

ENGINEERS' DICTIONARY.—XXIV.

Injector—A device for forcing the feed water into a steam boiler. As shown in Fig. 83, it consists essentially of a nozzle, *S*, connected with the upper pipe, *B*, leading steam from the boiler. When the steam is turned on by means of the handle *K*, and attached valve-stem and valve, it escapes in a jet which enters the slightly tapered passage *VC*. The air in the space around and between these two orifices is caught and drawn along with the jet, thus causing a defect of pressure at this point. This space is connected through the lower pipe, *B*, to the water reservoir, and when the loss of pressure is sufficient, the water rises the same as in the case of a pump. The water and steam are thus brought into contact, and pass on together into the combining and delivery tube, *CD*. The steam is here condensed, and the resultant jet of water attains a very high velocity. A little farther on, when this is reduced to the relatively low velocity of the water in the feed pipe, the pressure developed is sufficient to overcome the boiler pressure, to open the check valve, and to force the water into the boiler. While this result may seem puzzling, it may perhaps be an aid to a clearer understanding if we remember that it is the *energy* of the steam which is really the motive power. This is transformed largely into motion in the combined jet, and this, when arrested, gives the pressure as stated before. In a steam pump a steam piston is provided much larger than the water plunger in order to give a force sufficient to overcome the resistance in the feed pipe and at the check valve. So in the injector, in a somewhat similar manner, the energy of the steam in a relatively large pipe is concentrated on a small jet of water, giving it the high velocity and later the pressure as described.

It should be noted that as a boiler feeder a good injector has practically a perfect efficiency, all heat used being carried back again into the boiler, except the small amount lost by radiation from the instrument and connecting pipes.

An injector of the type shown in Fig. 83 is known as an *automatic* injector. This signifies that once the injector is adjusted and working, should the jet of water become broken by a jar or other accidental circumstance,

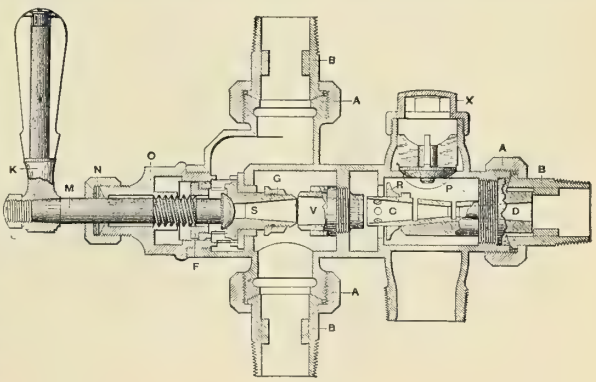


FIG. 83.

it will restart itself without further adjustment. The capacity and working range of an injector are decreased as the lift is higher and as the water is warmer. With cold feed water and a moderate lift, say not exceeding

5 to 8 ft., a good automatic injector will start up with 25 or 30 lbs. steam pressure, and will work with little or no further adjustment over a range of perhaps 100 lbs. pressure. With feed water at about 100° F. the same injector would start at 30 to 35 lbs. steam pressure and will work over a range of perhaps about 70 lbs. or up to about 100 lbs.

In addition to the automatic injector there is another type having two sets of tubes, one for lifting and one for forcing. Such instruments are often termed *inspirators* to mark the distinction from the ordinary automatic injector. When properly adjusted the lifting set of tubes acts as a governor to the forcing set, supplying under a great range of steam pressure the proper amount of water to condense the steam in the final set of tubes. Such an injector, handling cold water with a short lift, will work through a range of over 200 lbs., while with water as hot as 100° and small lift it will work through a range of from 150 to 200 lbs. The operation of each set of tubes is on the same principle as already described for the automatic injector.

Inspirator—See INJECTOR.

Jacket—A space surrounding the cylinder of a steam engine and filled with steam from the boiler. This space is made by the insertion of a shell or liner within the barrel or cylinder proper, leaving a space between the two, as shown under CYLINDER in Fig. 42. The cylinder heads may also be cast with a double shell and space between for the same purpose. The heat from the steam in the jacket is expected to flow through the metal of the liner and to enter the cylinder, thus keeping up the temperature of the working steam and preventing a part, at least, of the condensation which naturally occurs. This is effected to a greater or less extent, and thus one of the losses in the working of steam in a steam engine is reduced in amount. The saving is effected, however, at the expense of the heat thus drawn from the jacket, and the operation is, therefore, an attempt to reduce one loss by introducing another. If the latter is less than the saving in the cylinder the net result will be a gain equal to their difference. If the latter is the greater of the two, the net result will be a loss, and if they are equal the net result will be no change in the economy of the engine. These relations account for the varying experience with jackets, but it now seems well assured that when properly fitted and operated, the result will show a gain of from 5 to 10 per cent over similar conditions unjacketed.

Jacket Drain—A pipe with valves and connections for draining off the water condensed in the jackets.

Jacket Safety Valve—An escape valve fitted to the steam-jacket space, in order to relieve the pressure should it rise to a point considered unsafe.

Jet Condenser—See CONDENSER.

Jet Propeller—A form of propeller consisting essentially of a pump which takes in water from outside the ship and discharges it again with an increased velocity sternward. The propulsive thrust arises from the reaction of the water upon the pump, which produces the change of velocity.

Advices from Glasgow report the commencement of work on the Watson designed steam yacht for James Gordon Bennett, proprietor of the New York *Herald*, at the Denny yard in Dumbarton.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—Will you kindly explain the use, construction and care of an evaporator? SUBSCRIBER.

A.—An evaporator is an apparatus for making fresh water to supply the loss in the boiler feed. Of the steam which the boilers supply, not all can find its way back through the feed. Small steam leaks may occur at the various joints, some of the auxiliaries may not send their steam to the condenser, the whistle may be used (as in foggy weather), and so in various ways losses of fresh water will occur. The proportion of such loss varies widely with the circumstances, but will often amount to 5 per cent. and more. In order to avoid making up this loss with salt water, the evaporator is provided.

A representative type of evaporator consists of a series of nests or coils of pipe contained within a chamber—a modern type of evaporator was described and illustrated by drawings in our issue of December last, page 273. The chamber has a salt-feed inlet, and steam from the boiler or from one of the receivers is passed inside the tubes. The heat in the steam passes through the tubes and forms steam or vapor of lower pressure on the salt water side. The chamber is connected with the condenser or with the L. P. receiver, and the steam formed in the evaporator is thus passed into the main circuit and serves to make up the loss as specified before. At the same time the water formed in the coils by the loss of heat is drawn or trapped out as it accumulates and returned to the feed, so that all steam formed on the salt-water side is a net gain for the fresh-water account. The coils on the outer or salt-water side become naturally coated with scale, so that they must be cleaned from time to time. To this end they are usually made removable, or arranged so as to be readily accessible through manhole openings in the shell. It is essential that the tubes be kept clean for efficient working of the evaporator.

In the operation of the evaporator the chief point requiring attention is the proper proportion between the amount and temperature of the inflowing steam and the pressure within the chamber on the salt-water side. If the pressure is low and steam is provided in excess, it may give rise to a violent ebullition or foaming which will carry some of the salt water along with the vapor formed, and thus introduce salt instead of fresh water into the circulating system. This condition must be guarded against by a proper control of the amount of steam admitted. In the way of general maintenance the condition of the tubes as regards scale is the chief point requiring attention and, of course, the tightness of the tube joints.

Q.—What has produced the best results on ships' bottoms in reducing water friction or adhesion thereon? R. J. K.

A.—Smooth polished copper or sheathing metal, an alloy rich in copper, has produced the best results in reducing skin resistance or drag between the surface of a ship and the water. There has been but little information on this subject published of late, and no records of tests of recent date, but it is safe to consider that among the various materials available for the covering of ships' bottoms, none is superior to copper sheathing. This form of covering may always be applied to wood hulls, but cannot be directly applied to iron or steel on account of the electro-chemical action which would result, accompanied by the serious corrosion of the metal of the ship. To avoid this the well-known custom of "sheathing" with wood first and then with copper is sometimes adopted, especially for naval ships which are to make long cruises without opportunity for docking, cleaning, and repainting.

For iron and steel hulls various paints are used, the points of superiority depending chiefly on the ability to adhere closely to the metal and thus furnish the protection required, and the property of poisoning or preventing the growth of the various forms of marine life which are liable to attach themselves to ships' bottoms. Various so-called "copper" paints or other special protective and anti-fouling compositions seem to have given fairly satisfactory results, but no form of painted surface will long retain its original smoothness, and at intervals, longer or shorter according to circumstances, the ship must be docked and the bottom repainted. At best the painted surface is inferior to copper sheathing, the difference ranging from 5 to 10 per cent. according to various tests.